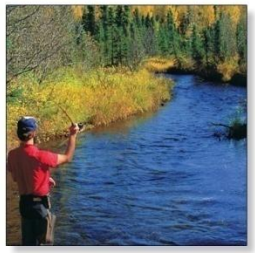
Introduction to PEST

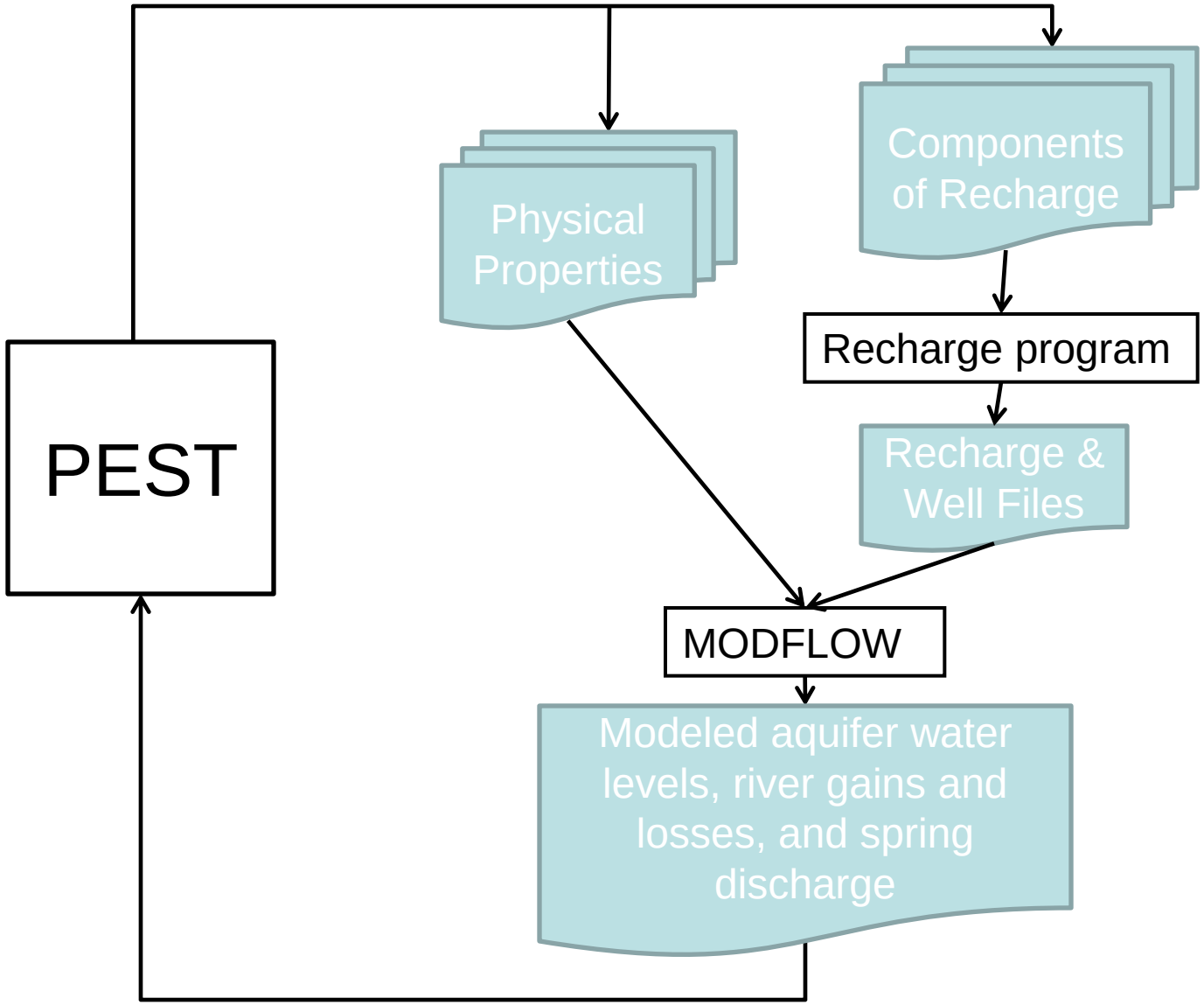
Presented by Allan Wylie, IDWR

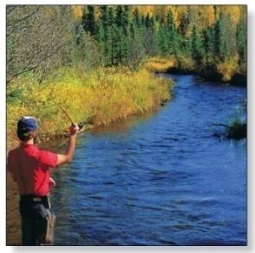
Date February 6, 2014



Outline

- Flow diagram
- What IS the MODEL
- PEST


Physical Properties
Components of Recharge
Recharge program
Recharge & Well Files
PEST
MODFLOW
Modeled aquifer water levels, river gains and losses, and spring discharge

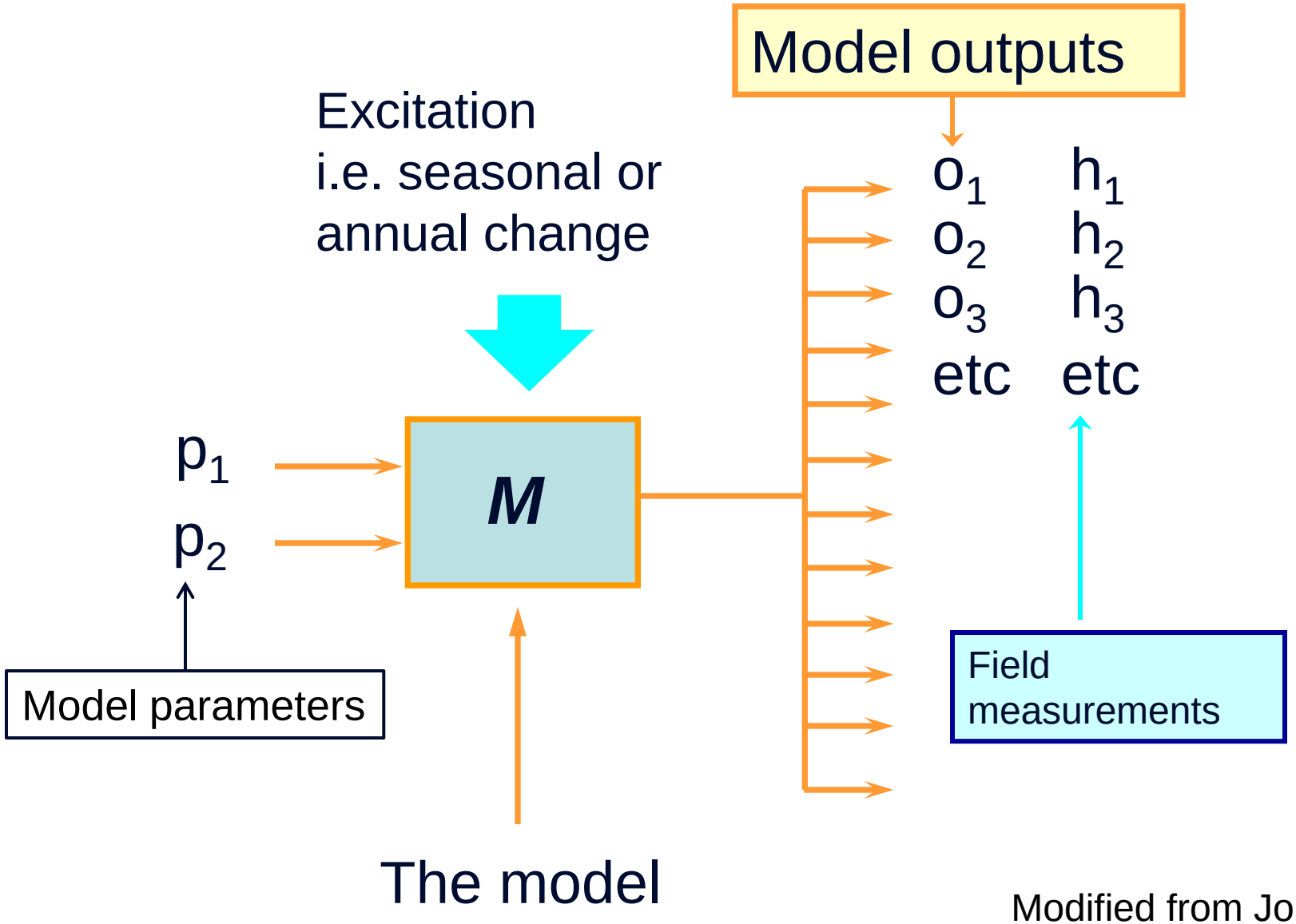


The Model

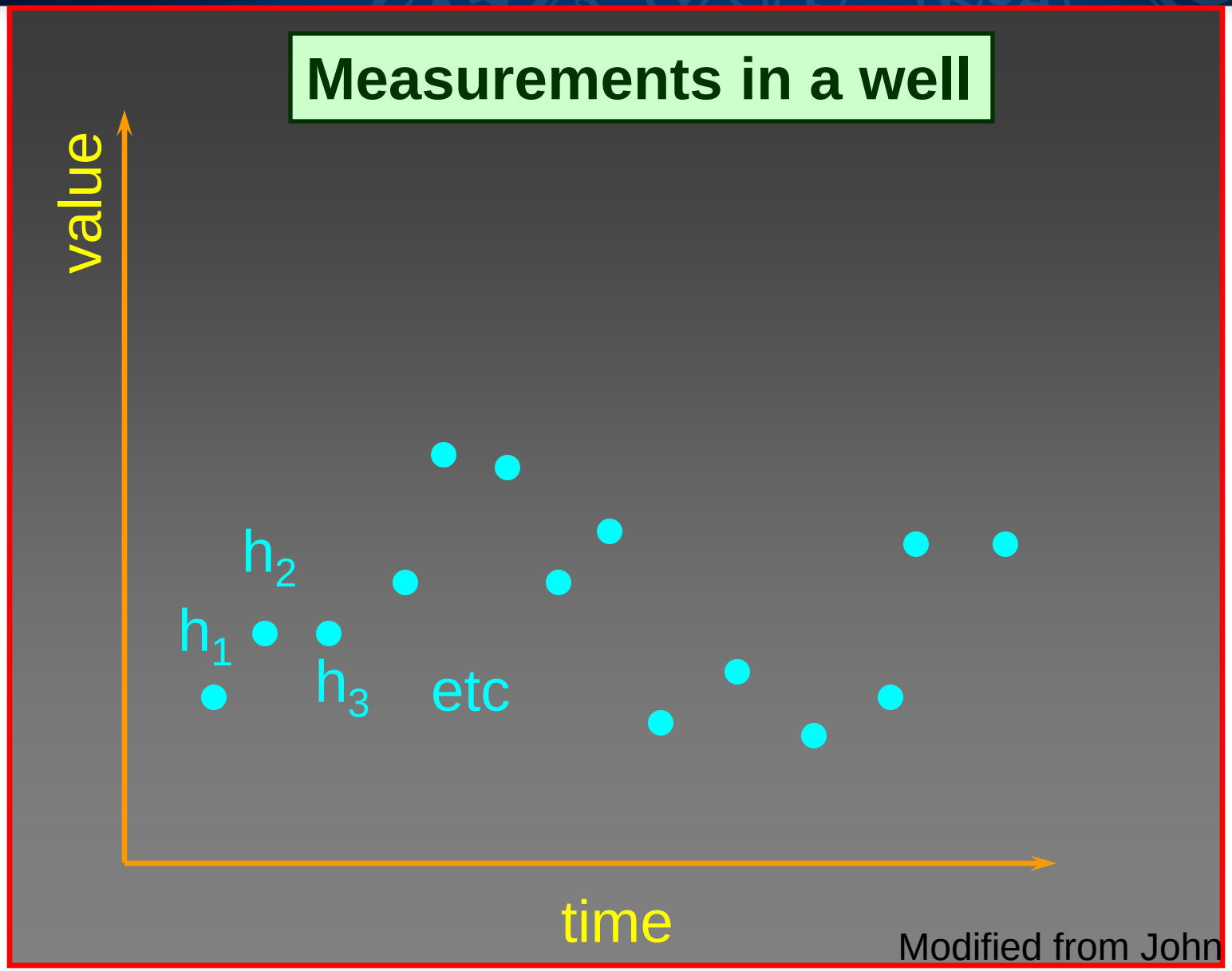
- Preprocessing programs
- MODFLOW
- Post-processing programs

Calibration Tool

- PEST
  - Compares model output with observations
    - River aquifer interactions
    - Spring discharge
    - Water levels in wells
  - Objective is to minimize difference between modeled and observed values
  - Prepares input files
    - MODFLOW
    - Recharge Program



Modified from John Doherty



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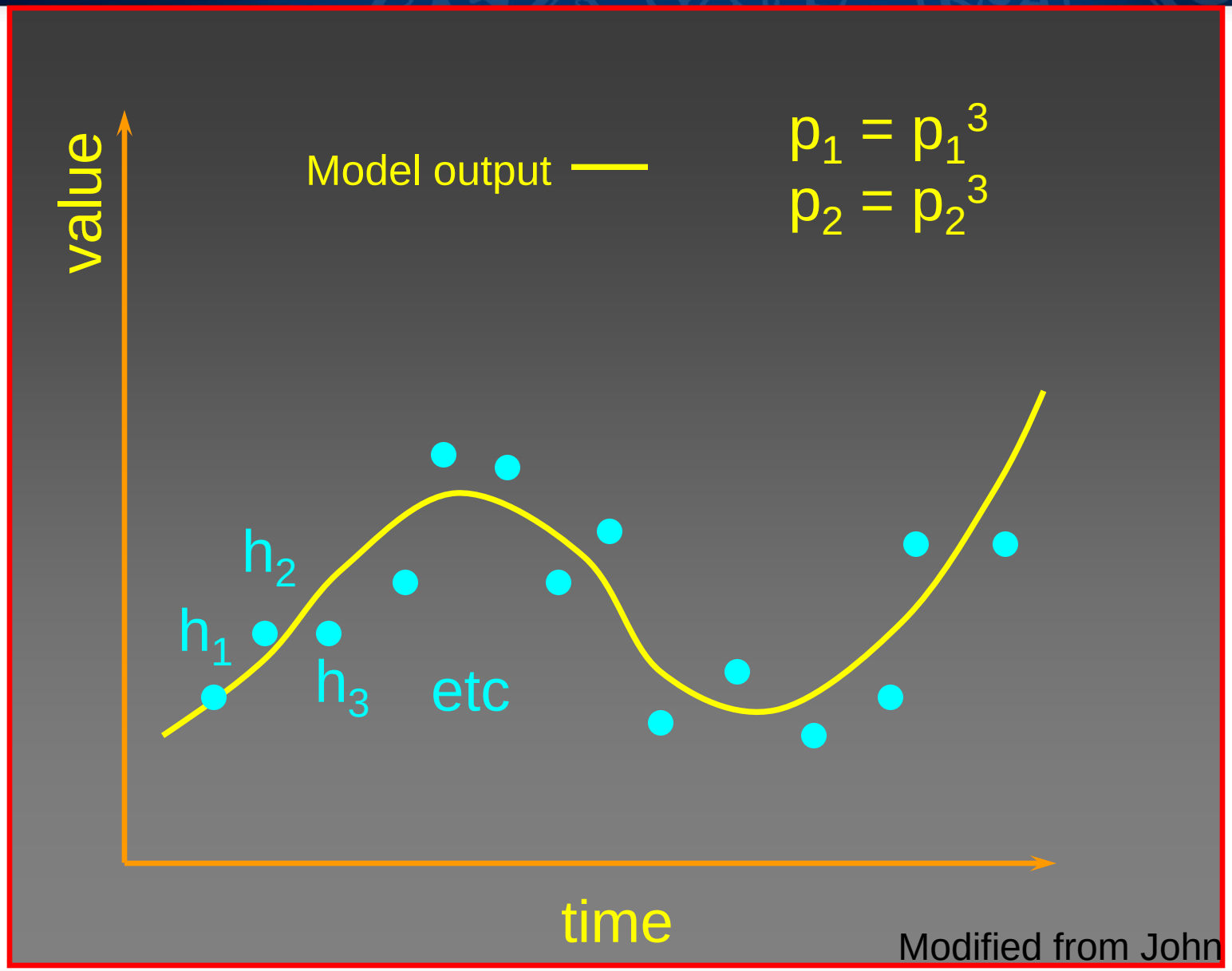

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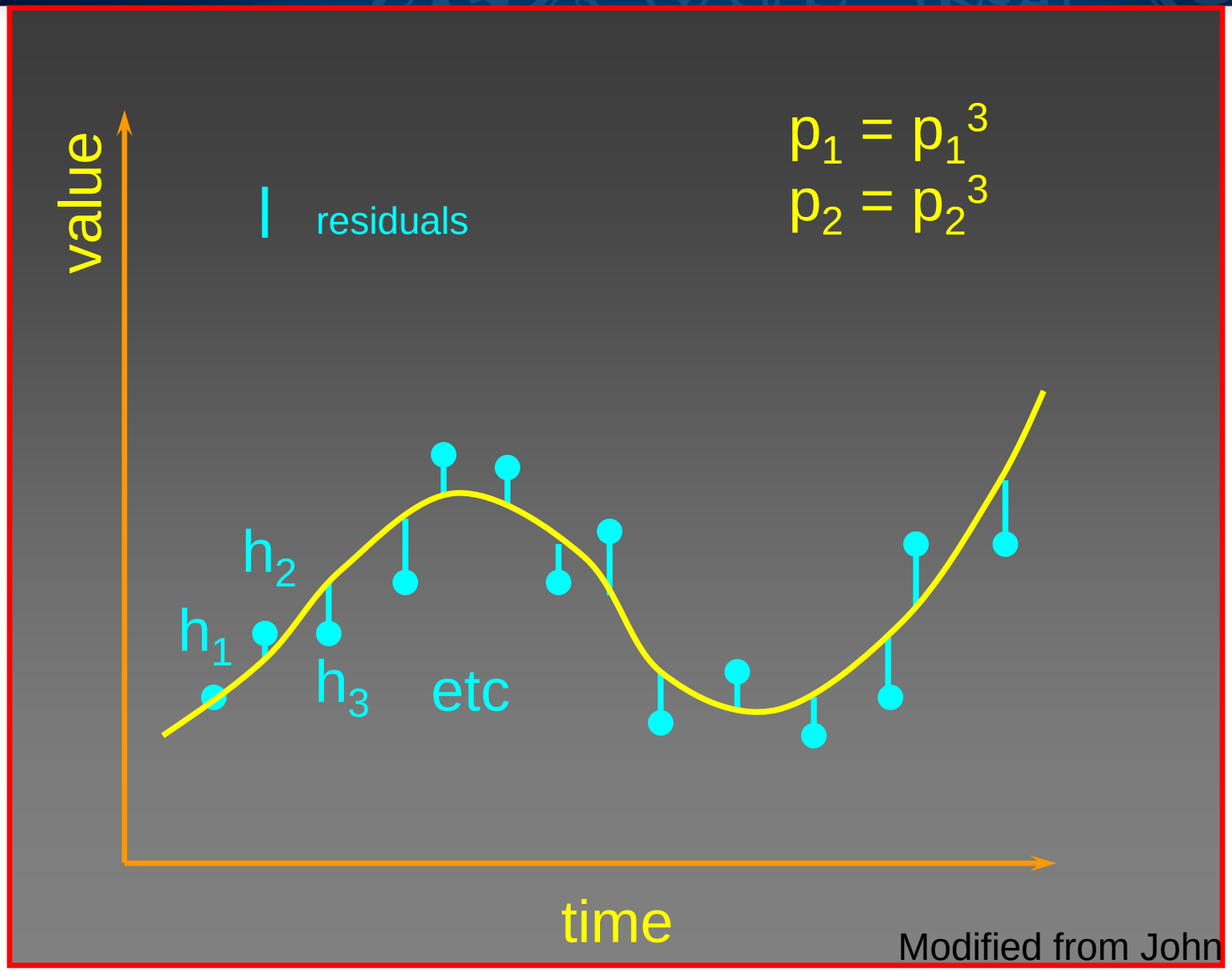

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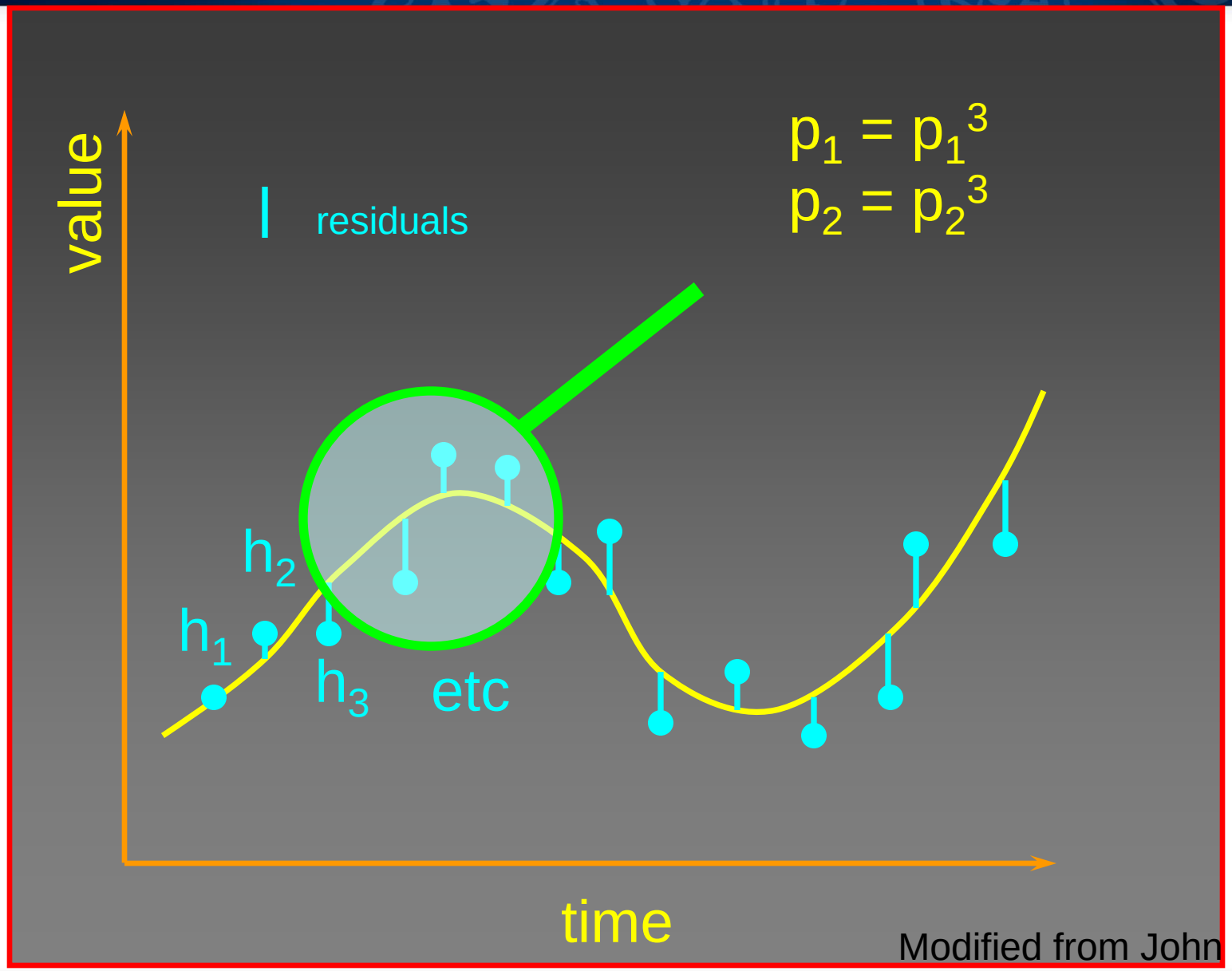

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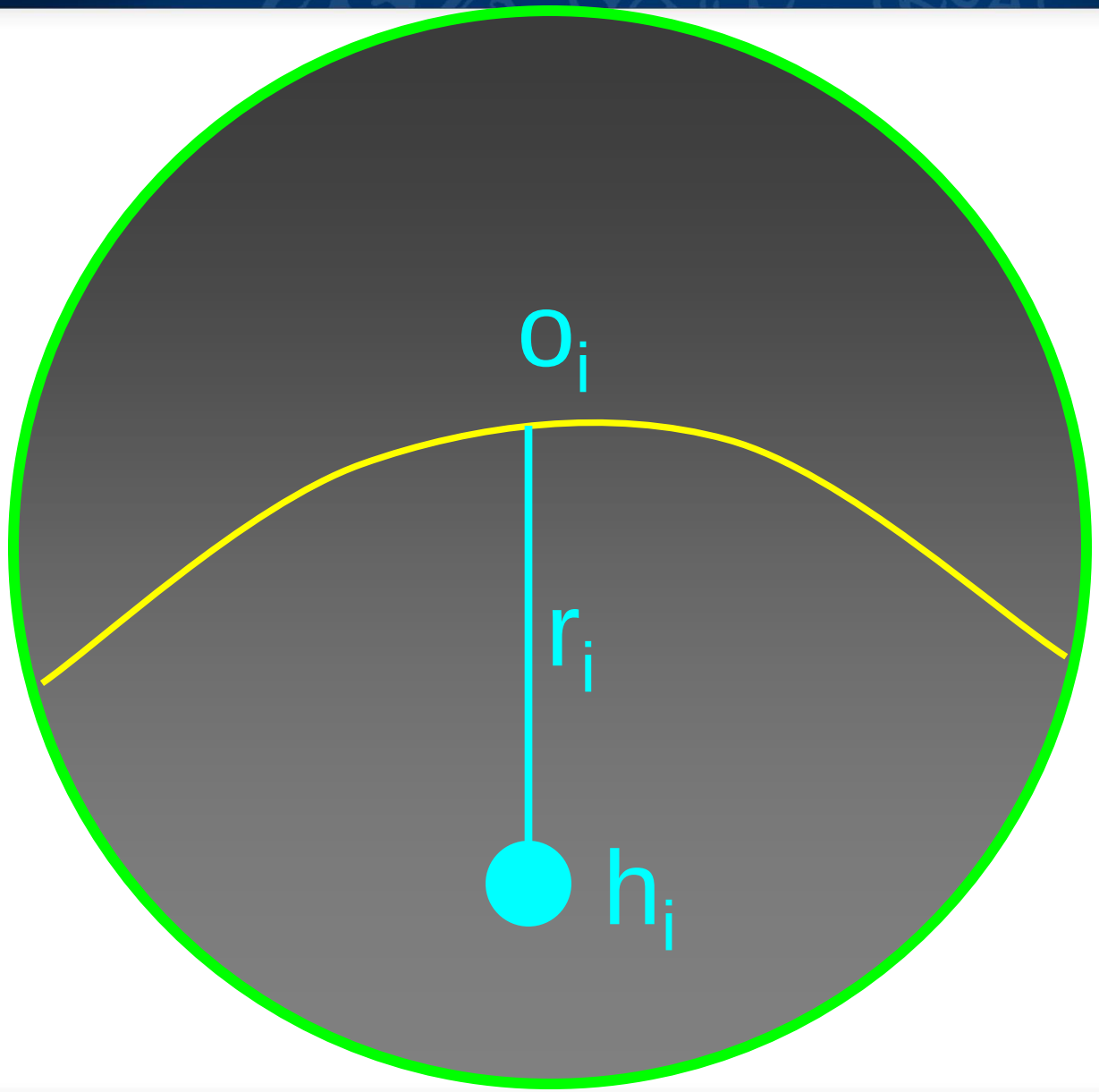
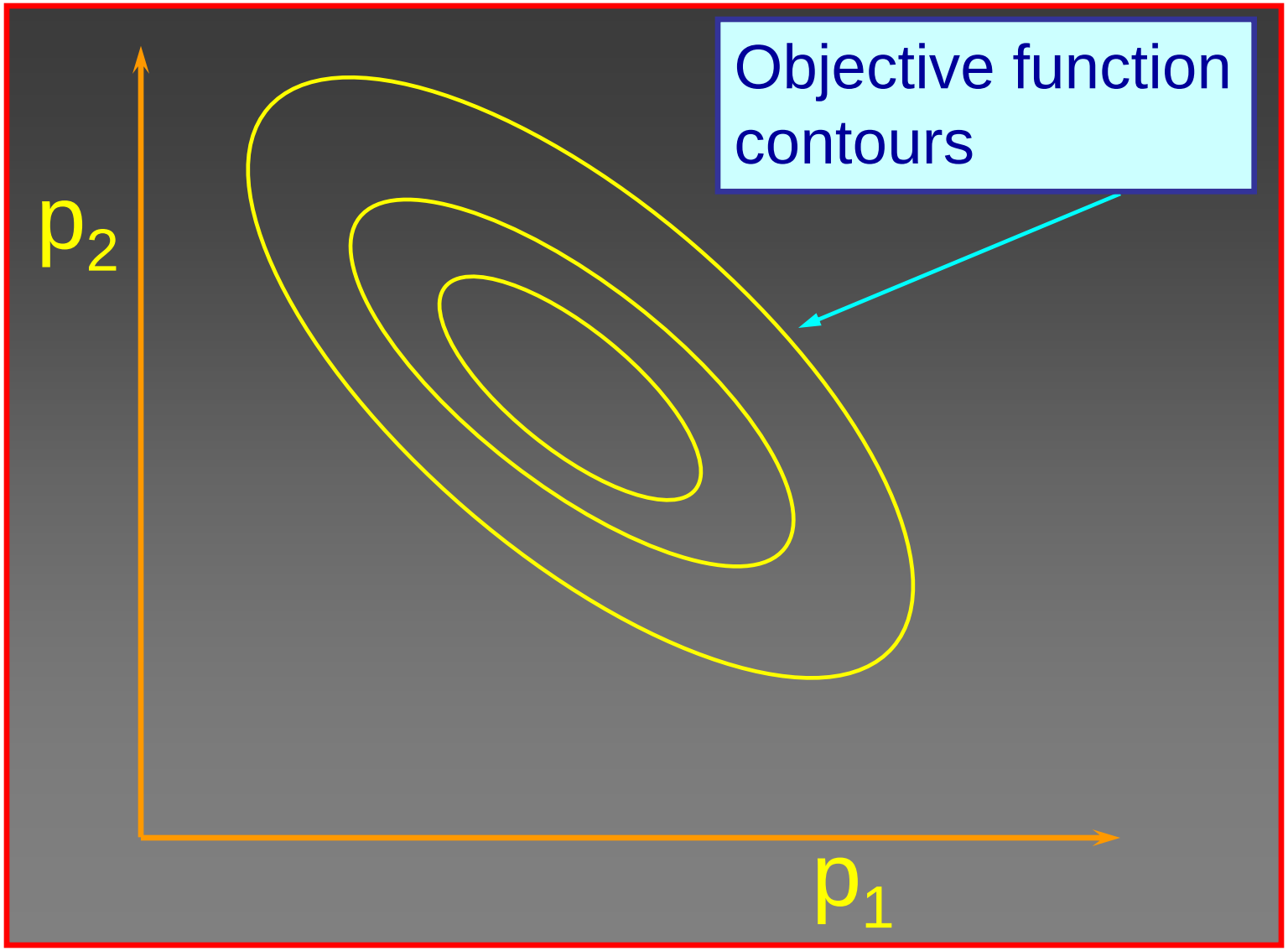
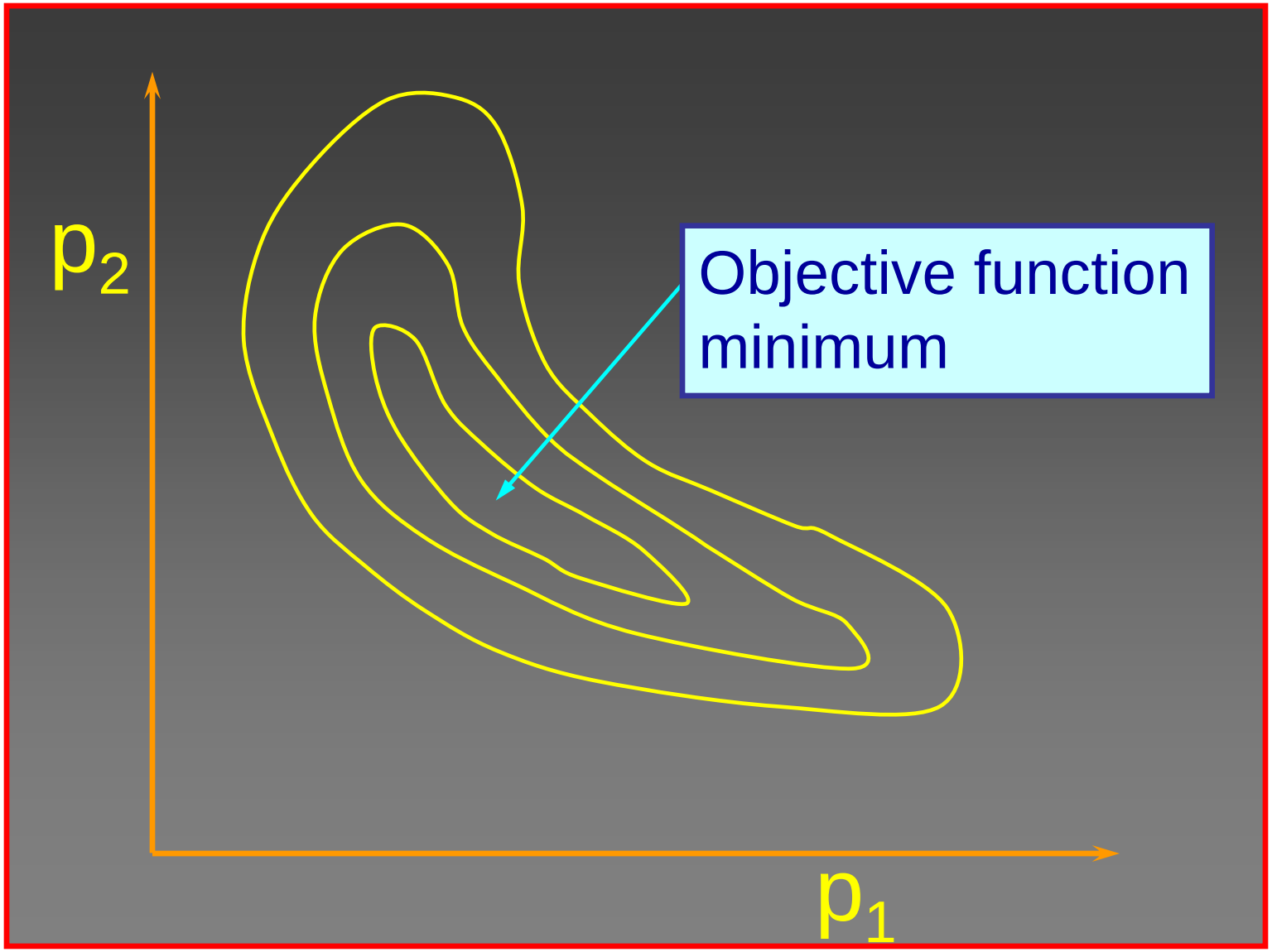
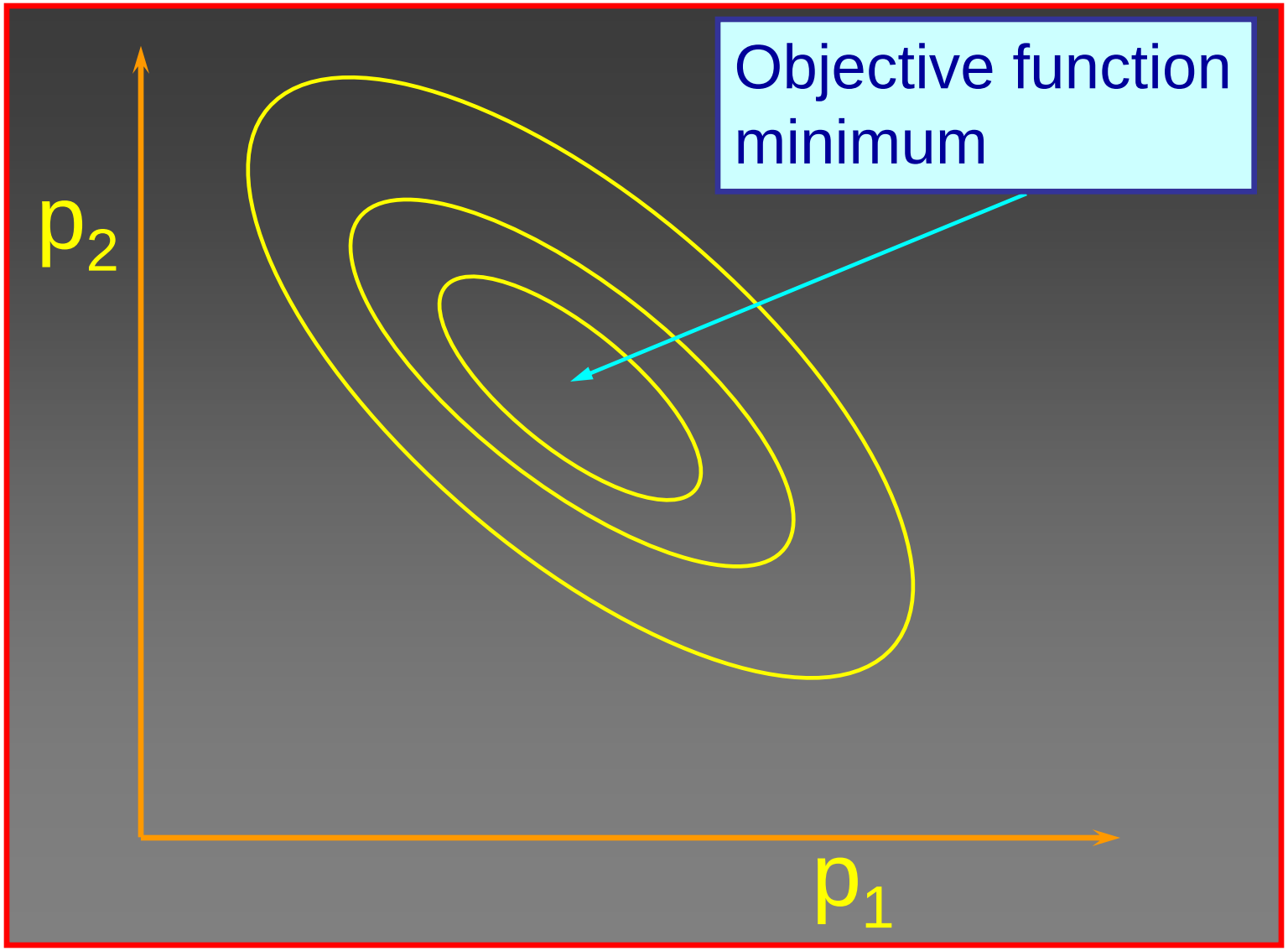

o_i
r_i
h_i

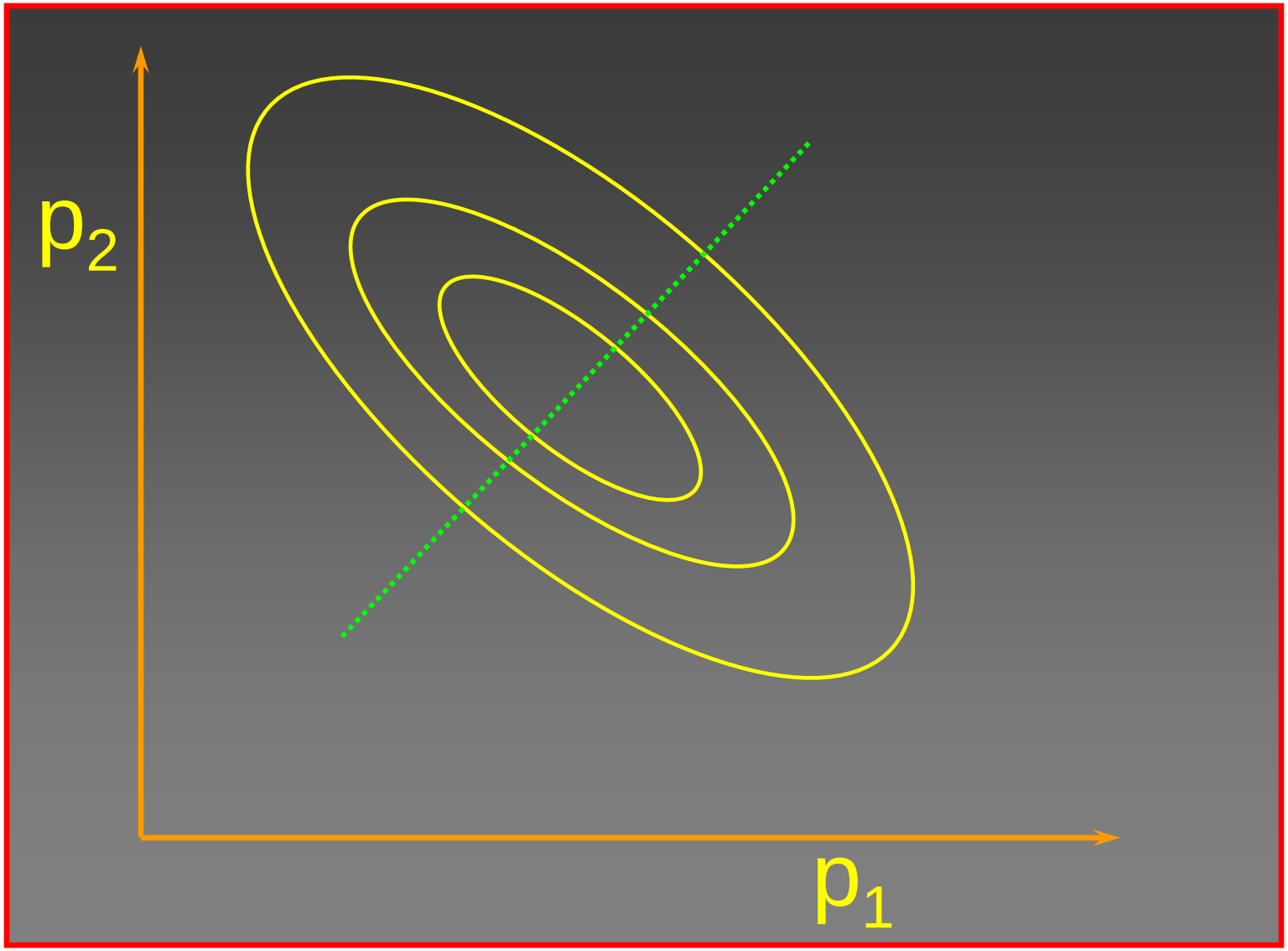
$$= \Sigma \left(h_i - o_i\right)^2$$

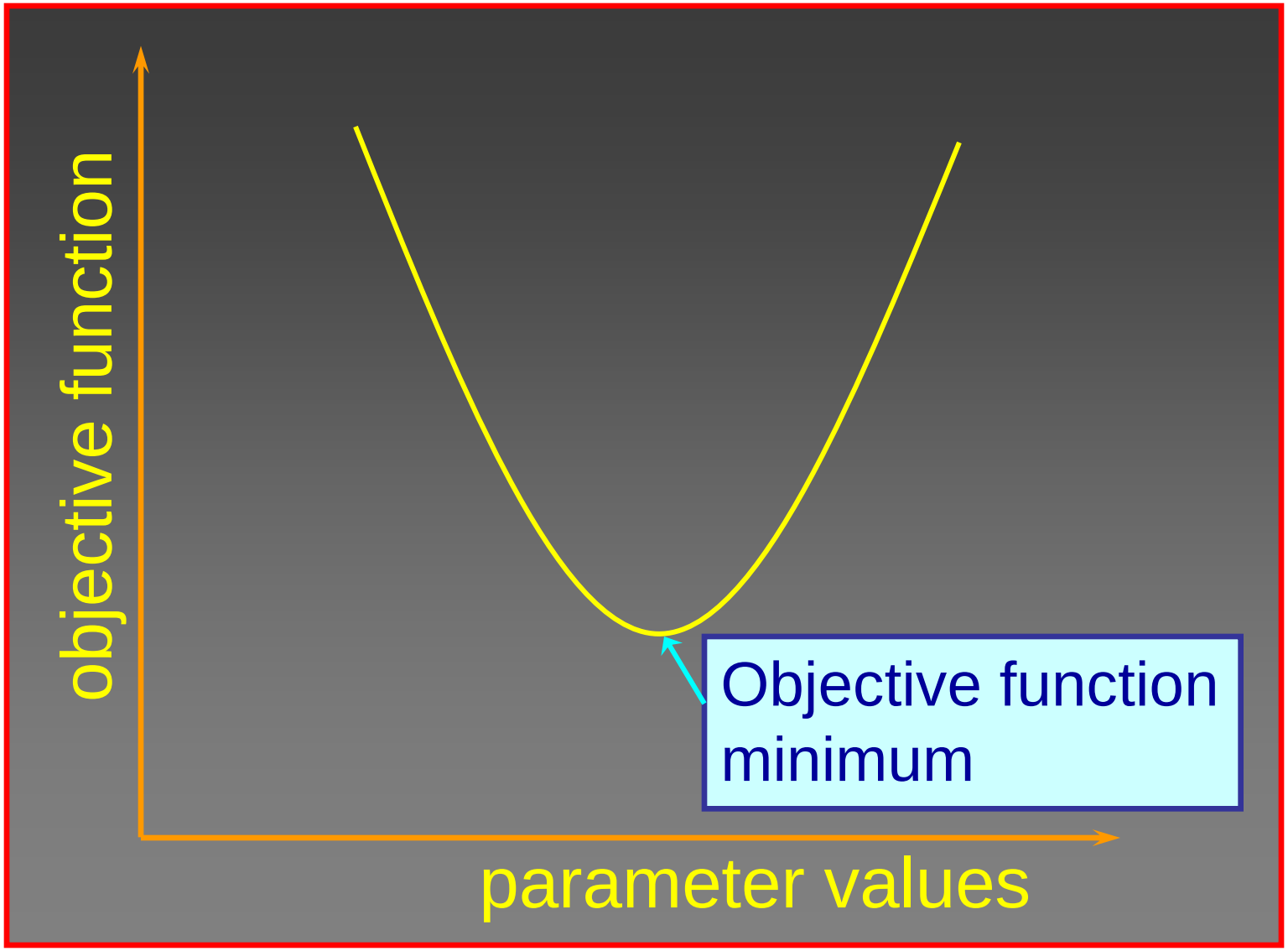
$$= \Sigma\, r_i^2$$

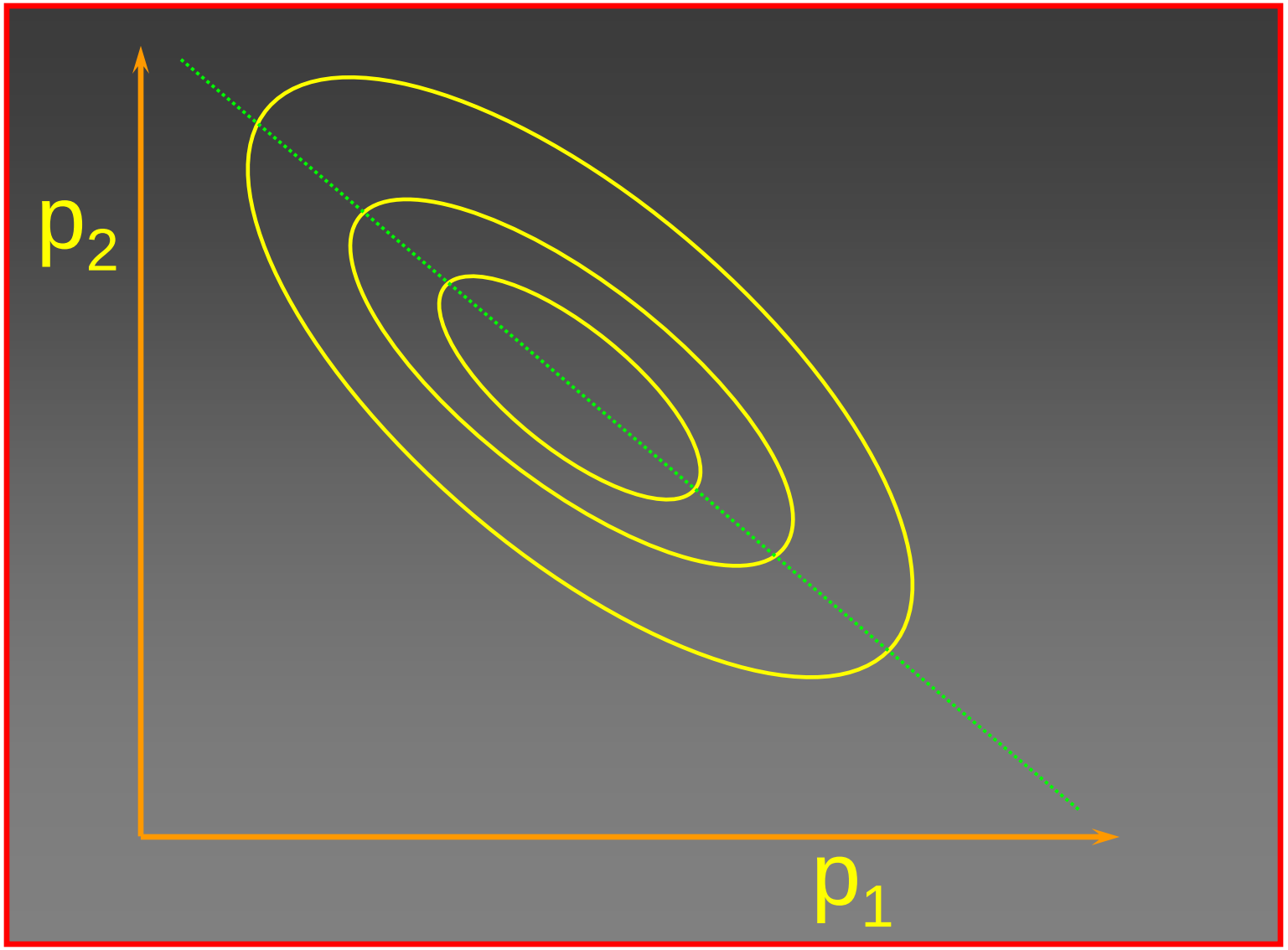

Objective function contours
p_2
p_1

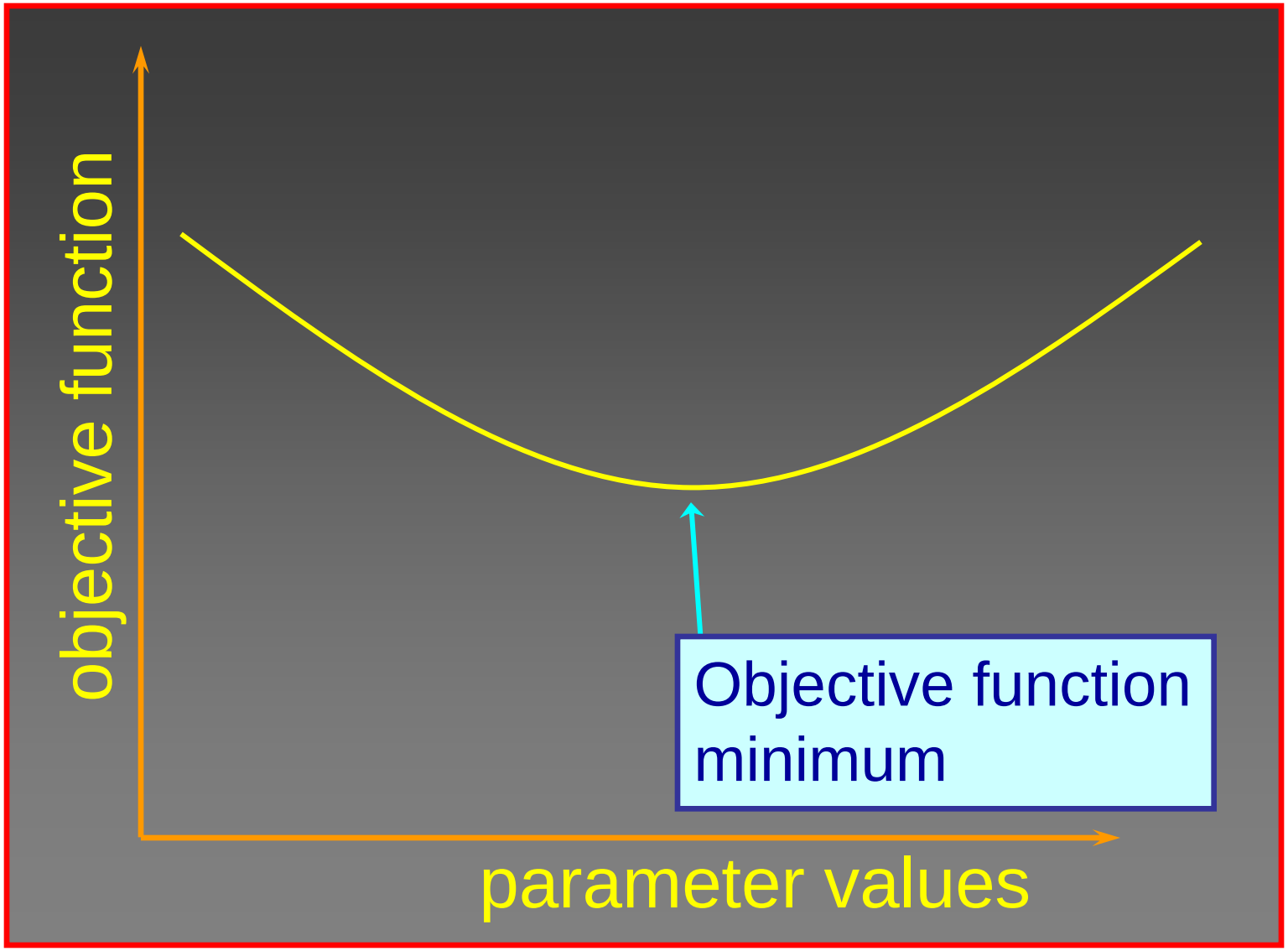

p_2
Objective function minimum
p_1

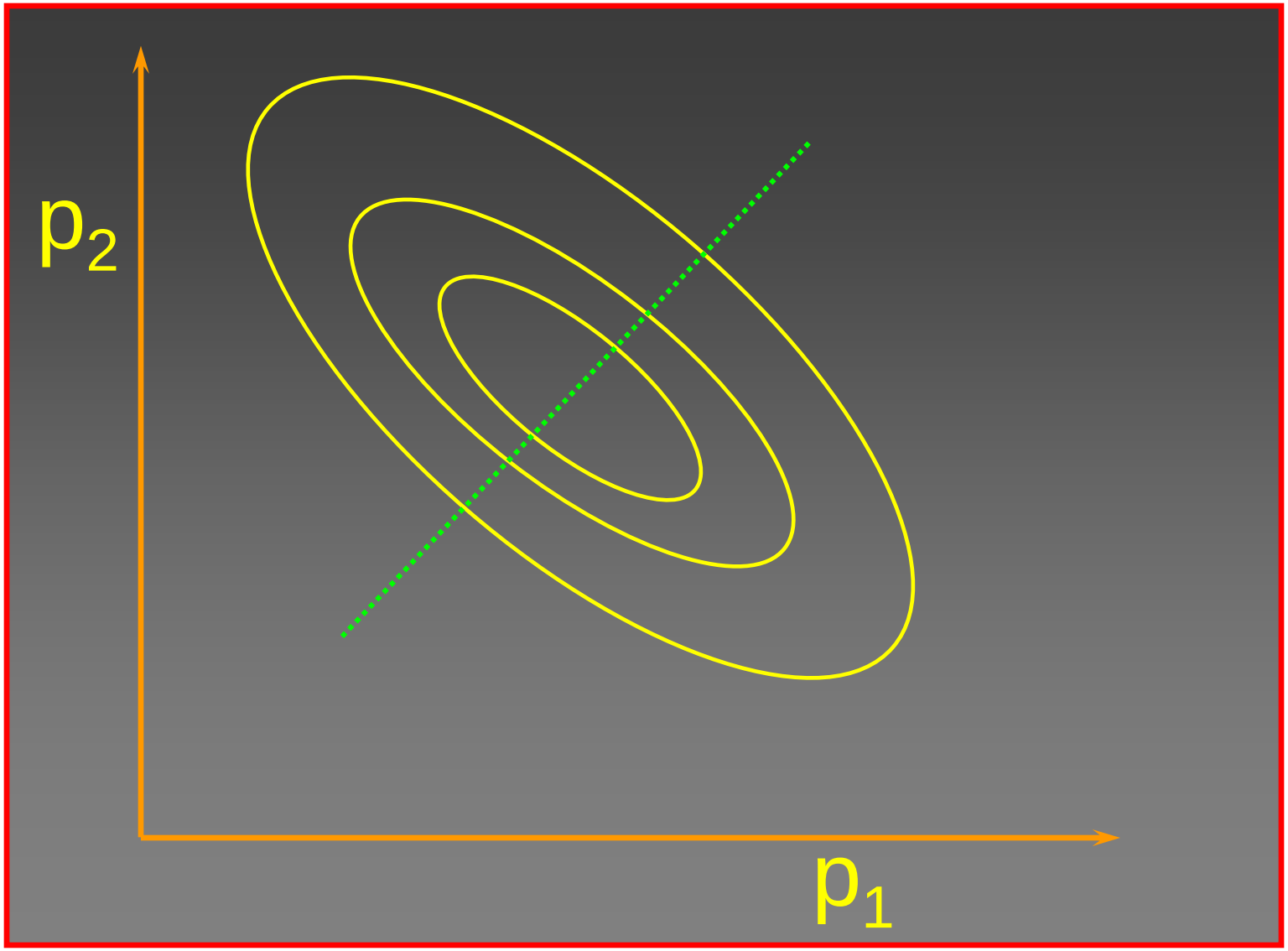

Objective function minimum
p_2
p_1

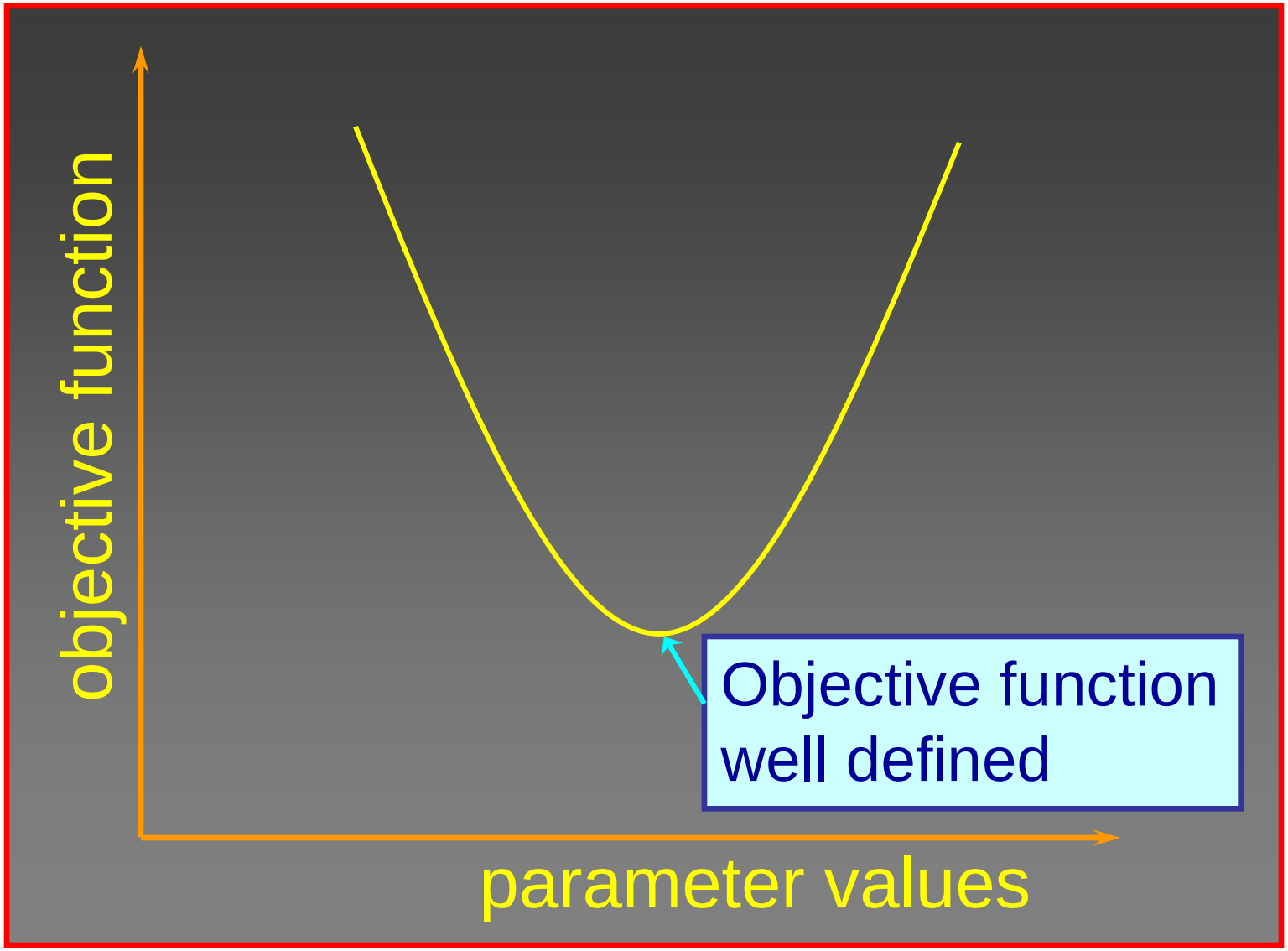

p_2
p_1

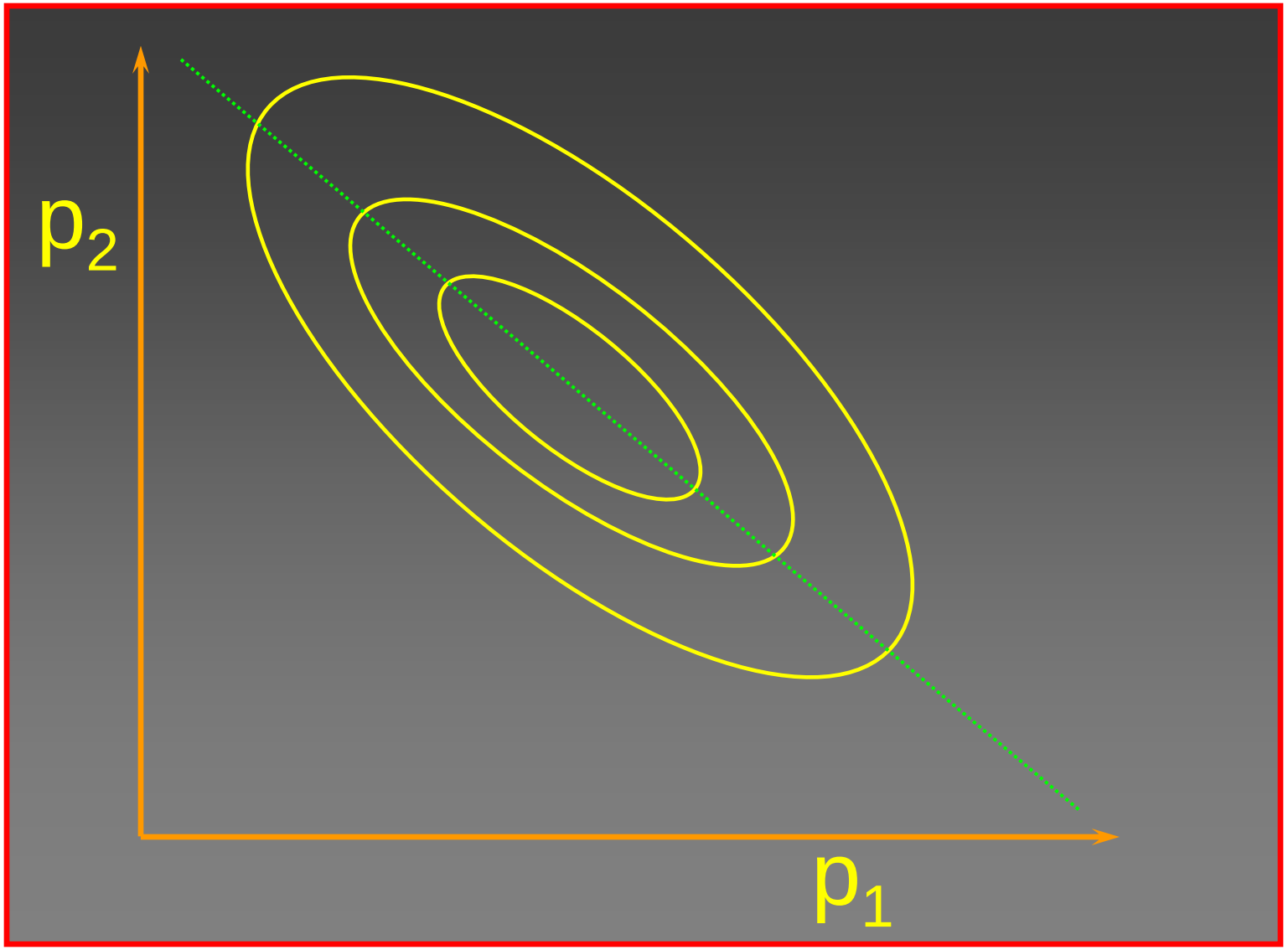

objective function
parameter values
Objective function minimum

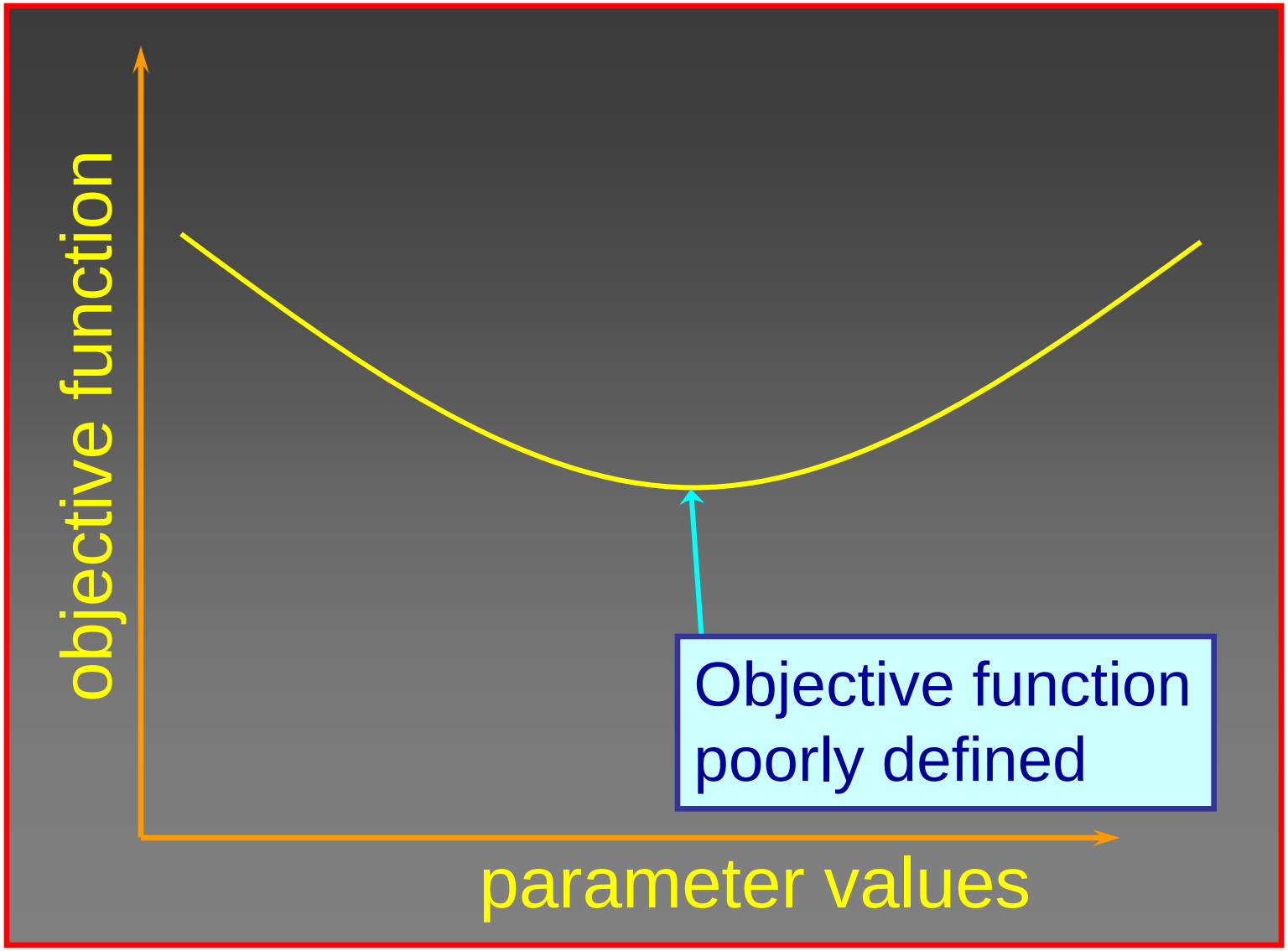

p_2
p_1

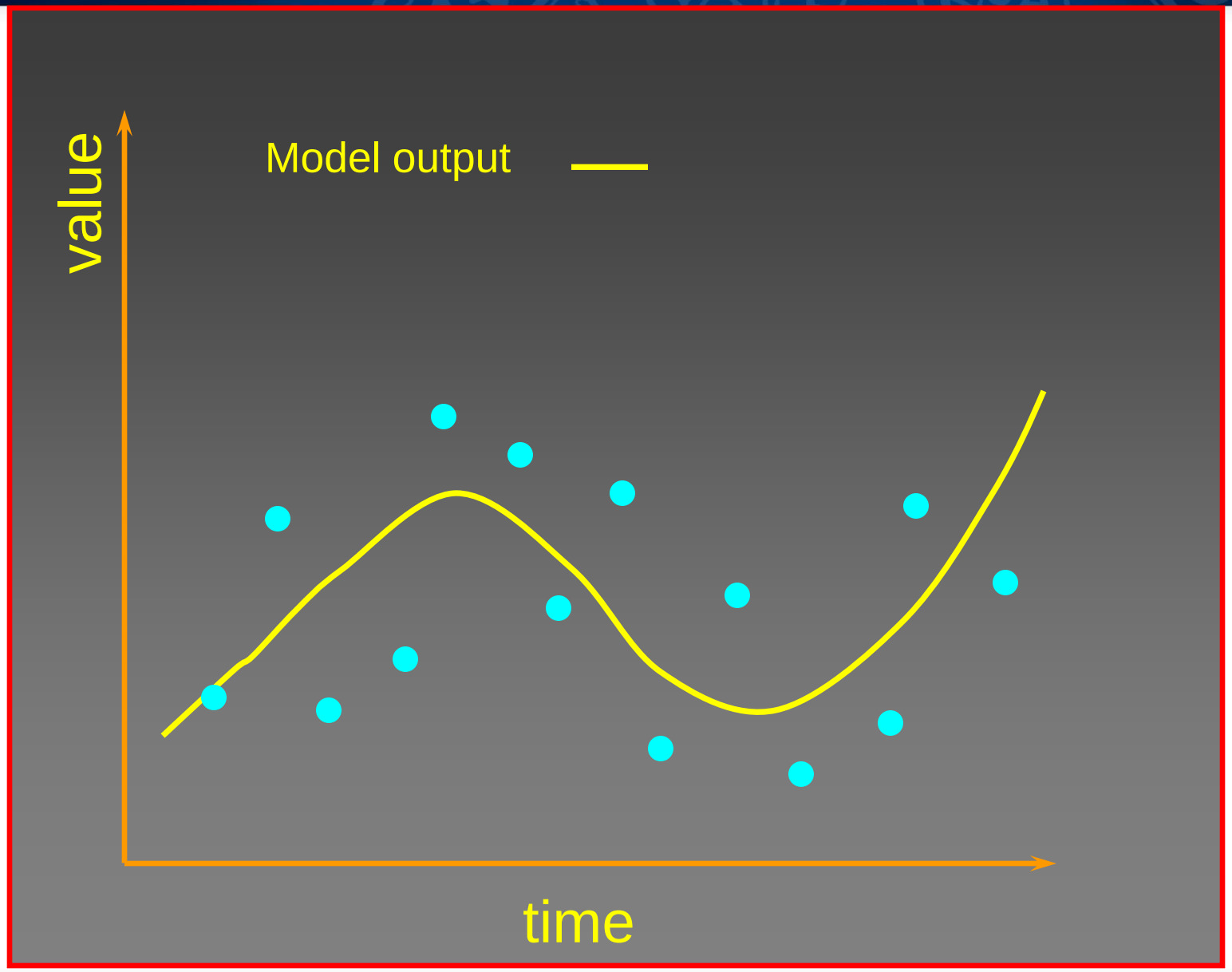

objective function
parameter values
Objective function minimum

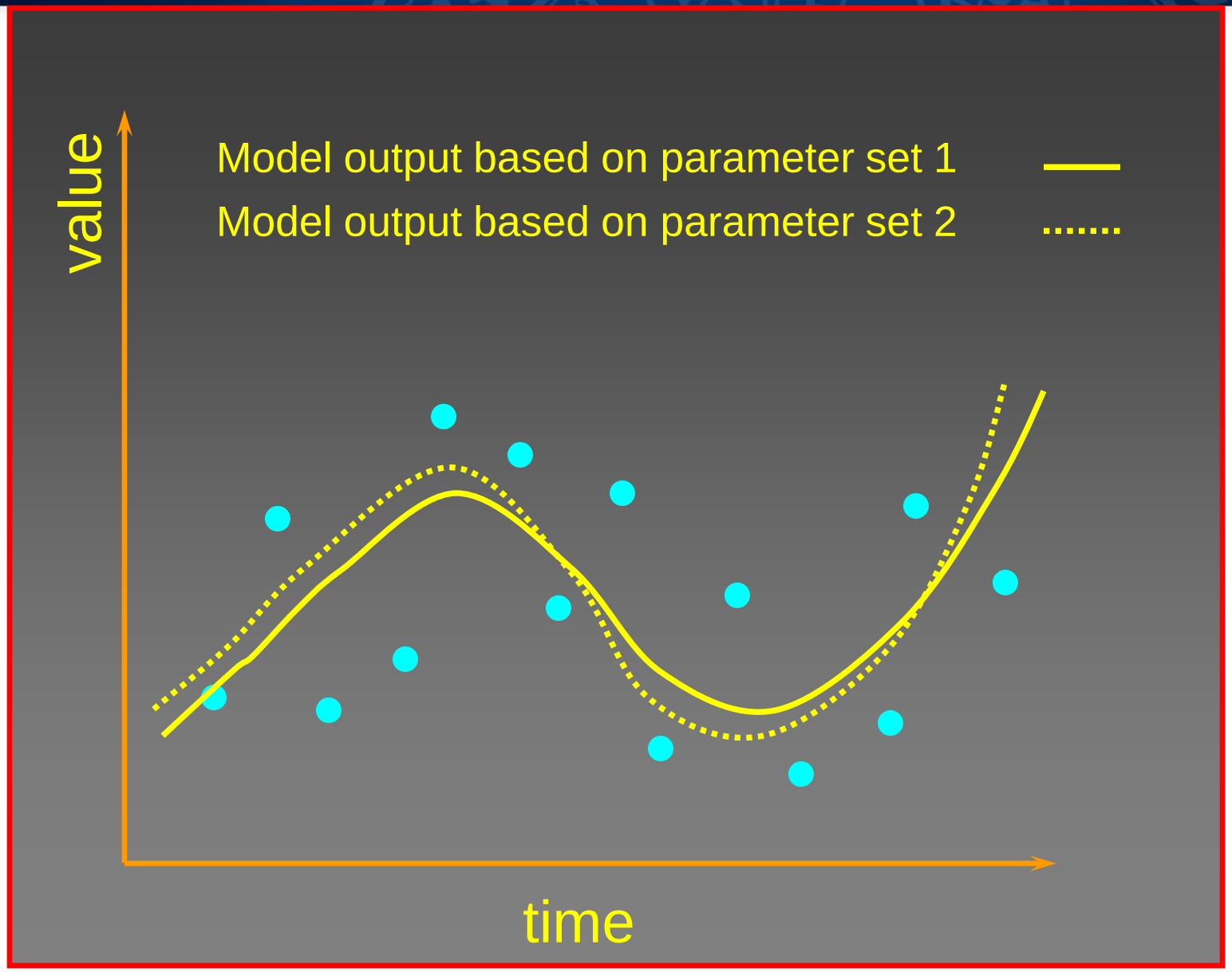

p_2
p_1

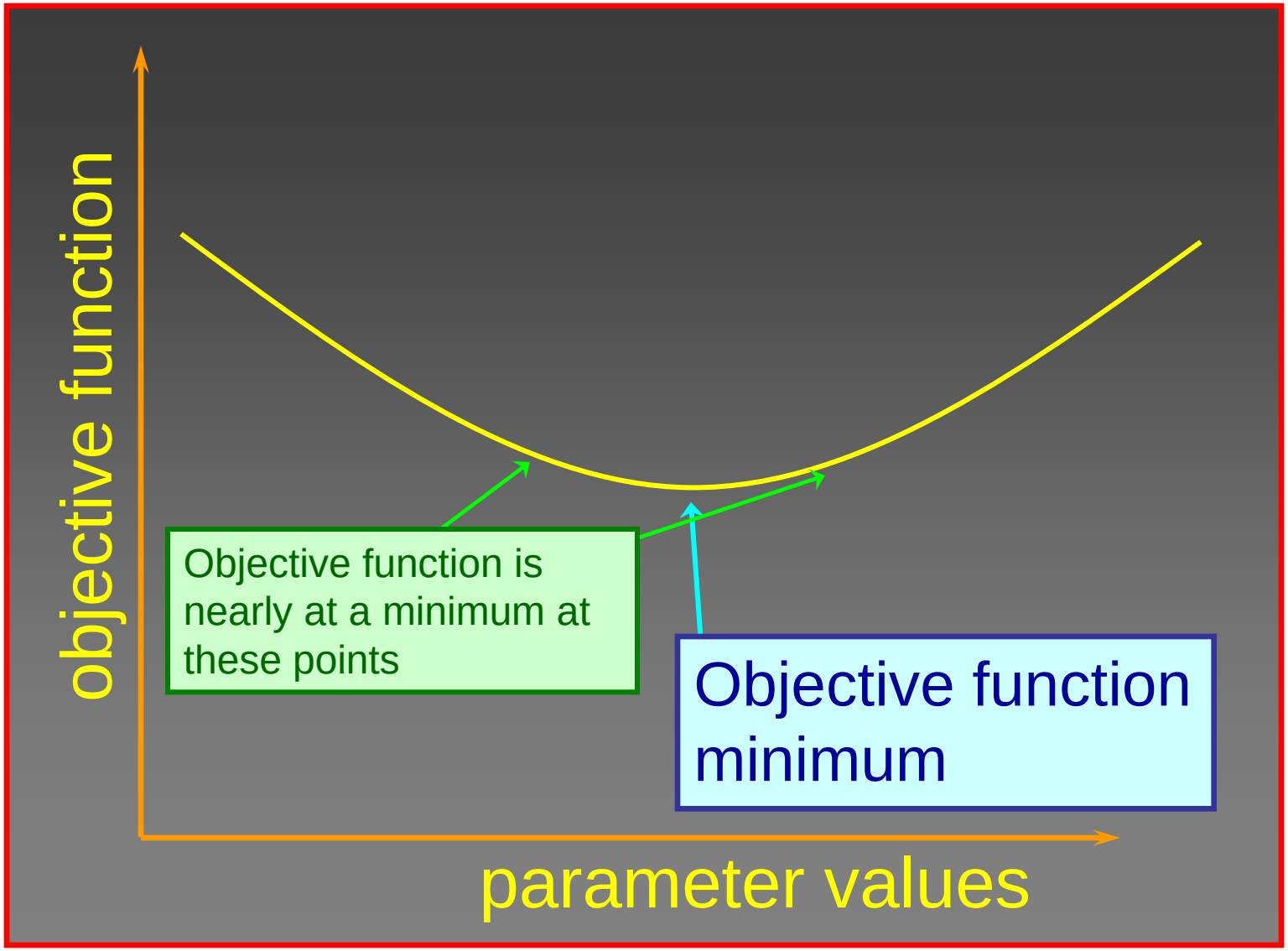

objective function
parameter values
Objective function well defined

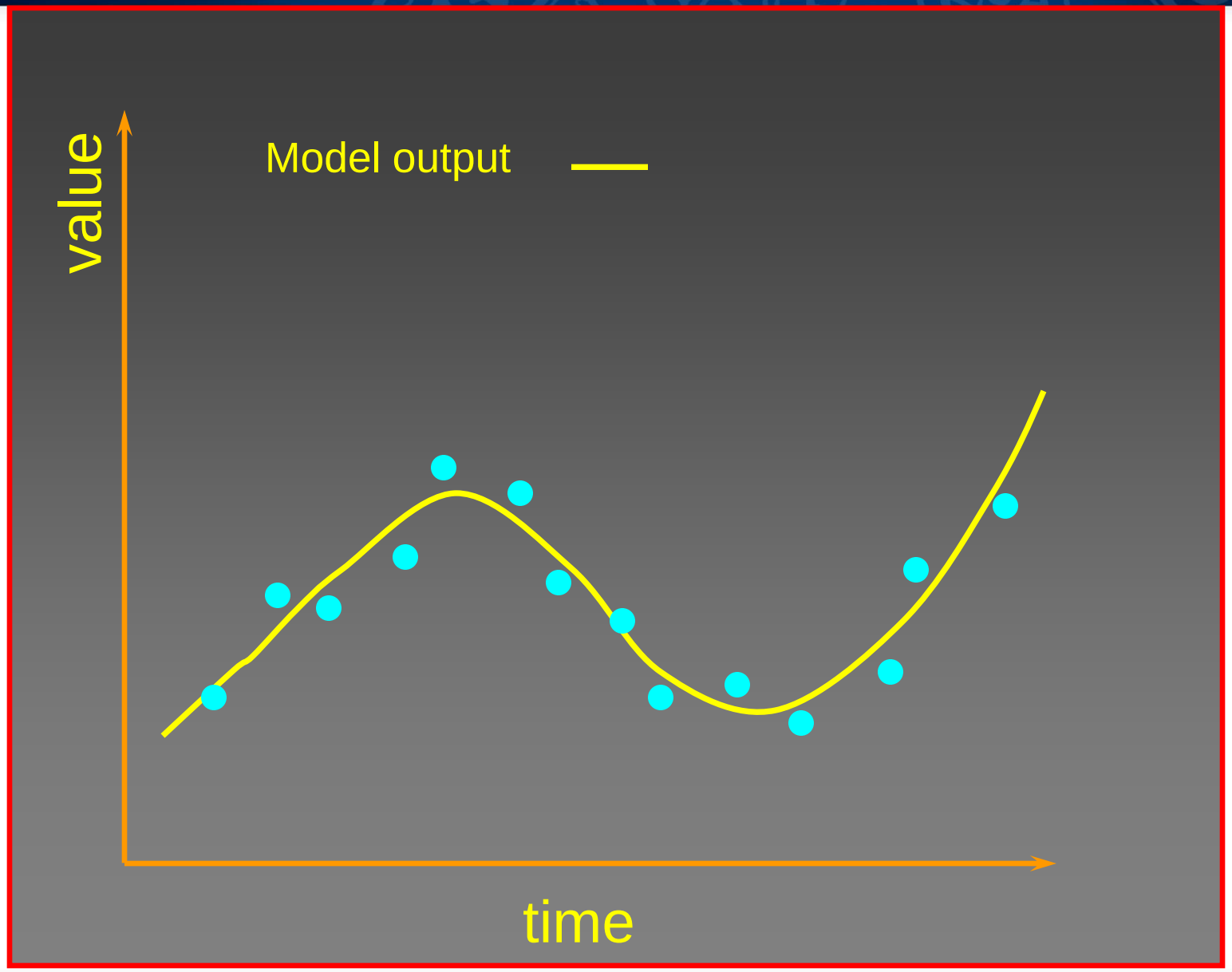

p_2
p_1

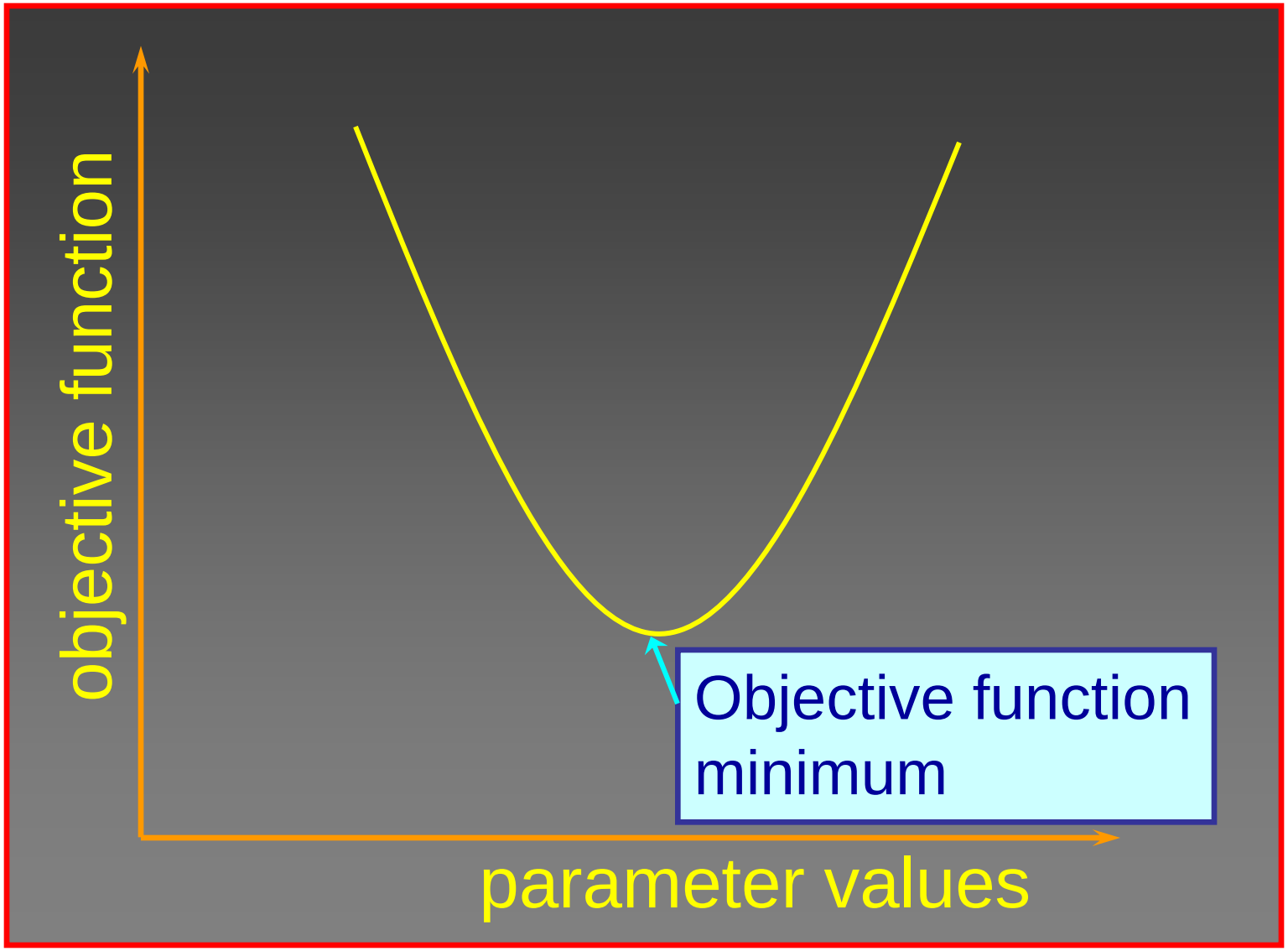

objective function
parameter values
Objective function poorly defined


Model output
value
time


value
Model output based on parameter set 1
Model output based on parameter set 2
time


objective function
parameter values
Objective function is nearly at a minimum at these points
Objective function minimum


Model output
value
time


objective function
parameter values
Objective function minimum

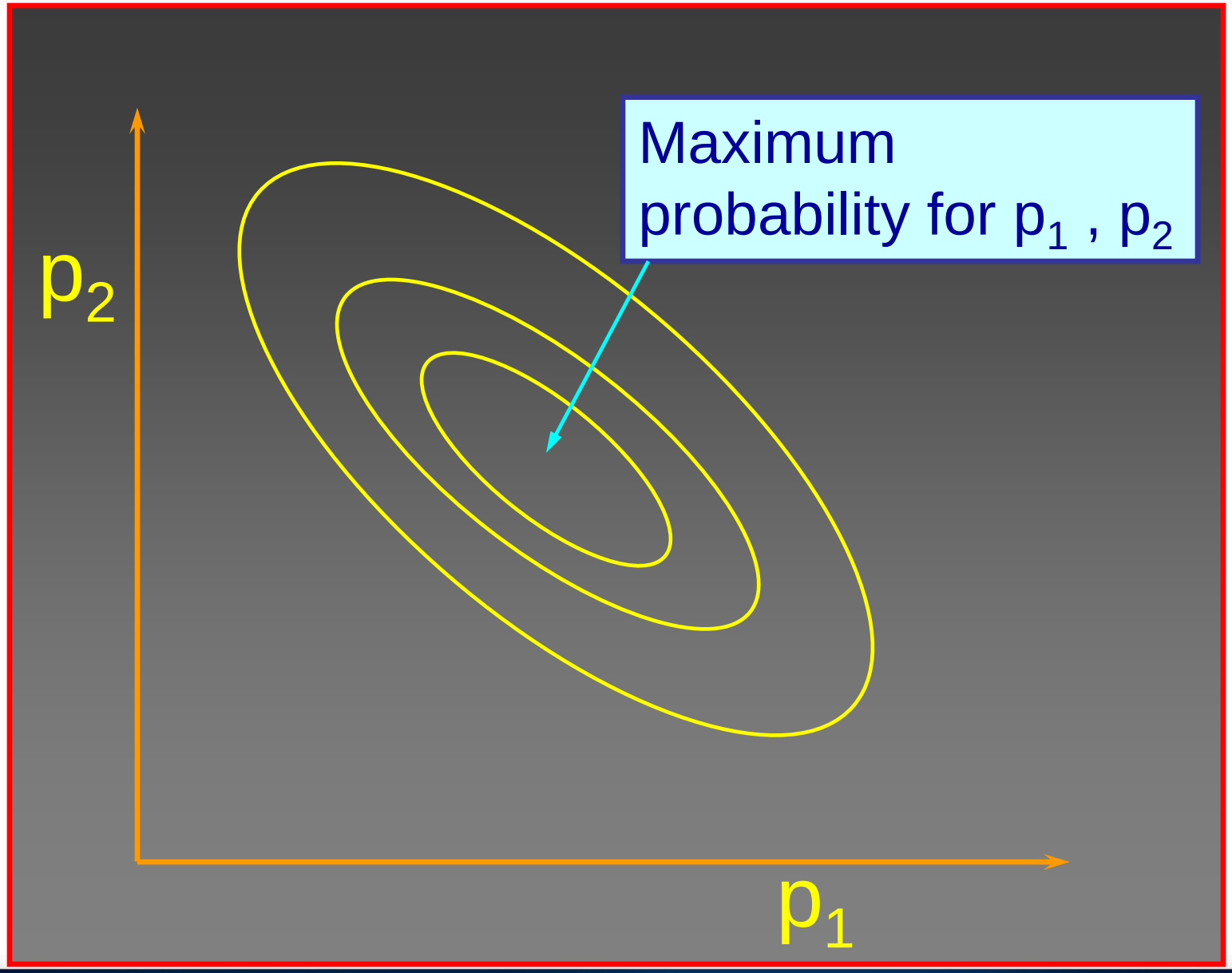
Things that make the objective function less distinct

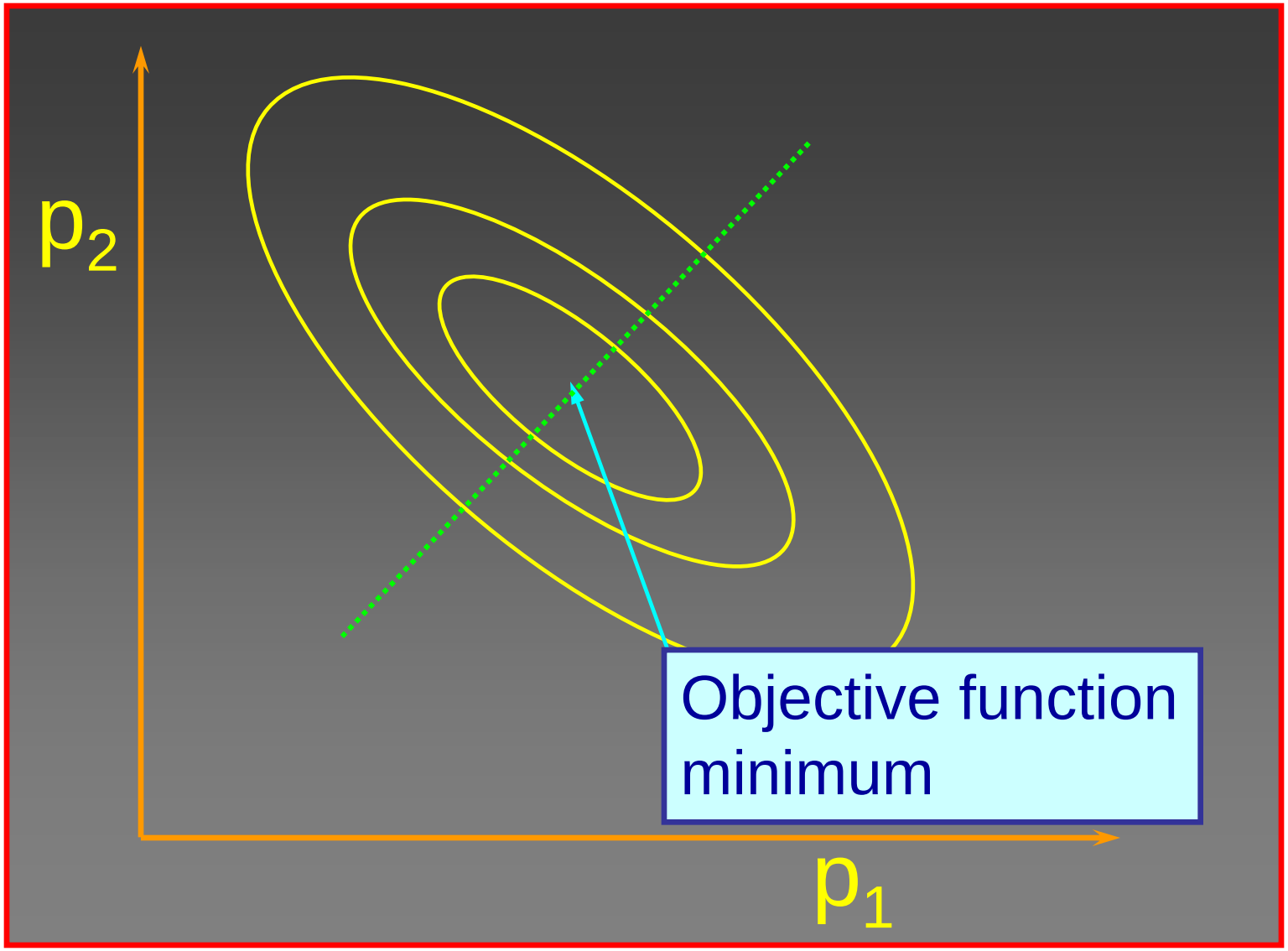
- Noise in the data
  - Noise is opposite of information
- Data density
  - Sparse data does not tightly constrain calibration
- Poor model suitability
  - Model fails to account for all the factors salient to the prediction
- Correlation between parameters

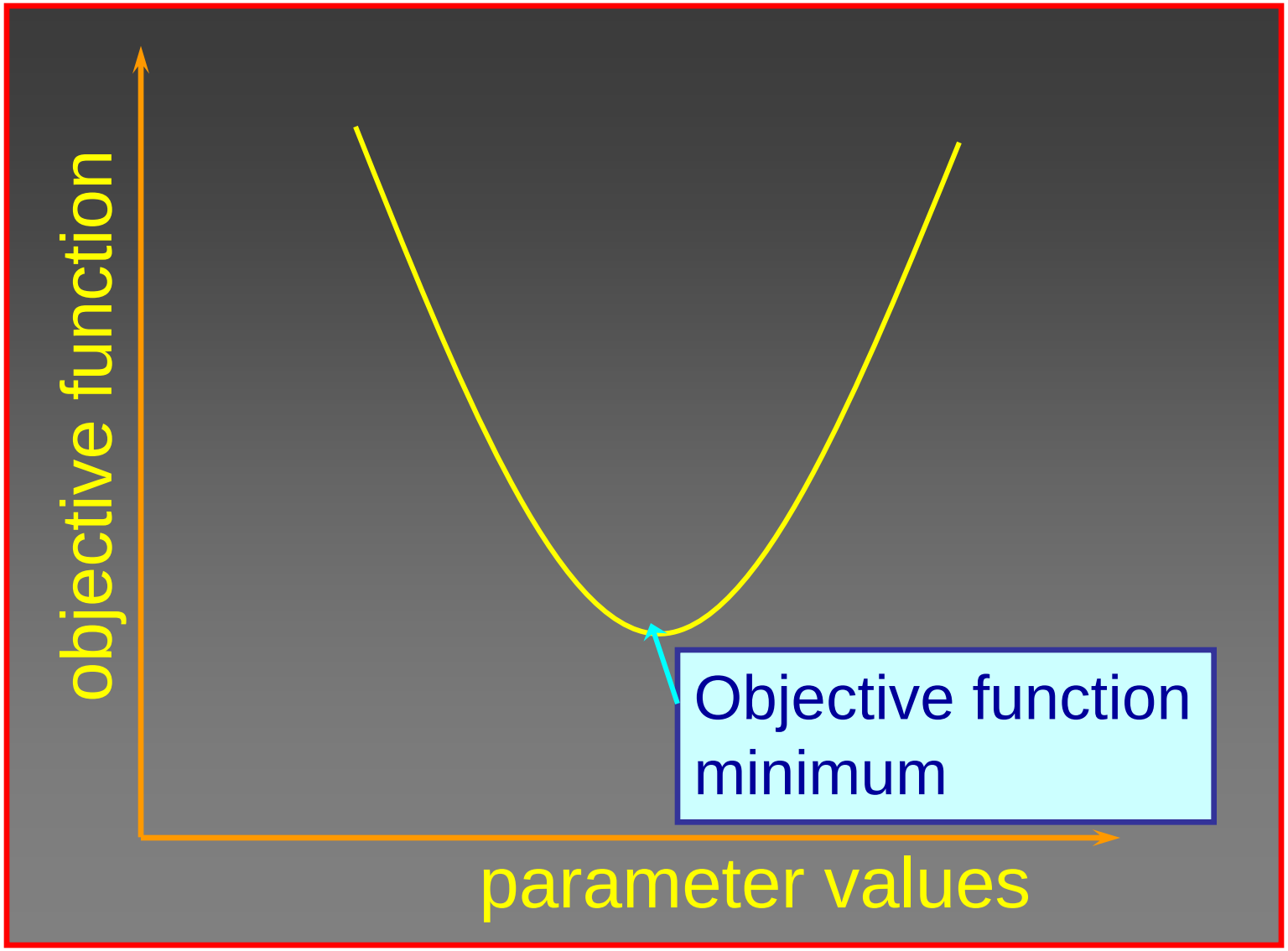
- Some parameters can be estimated with greater certainty than others
- Relevant data with minimal noise constrains objective function

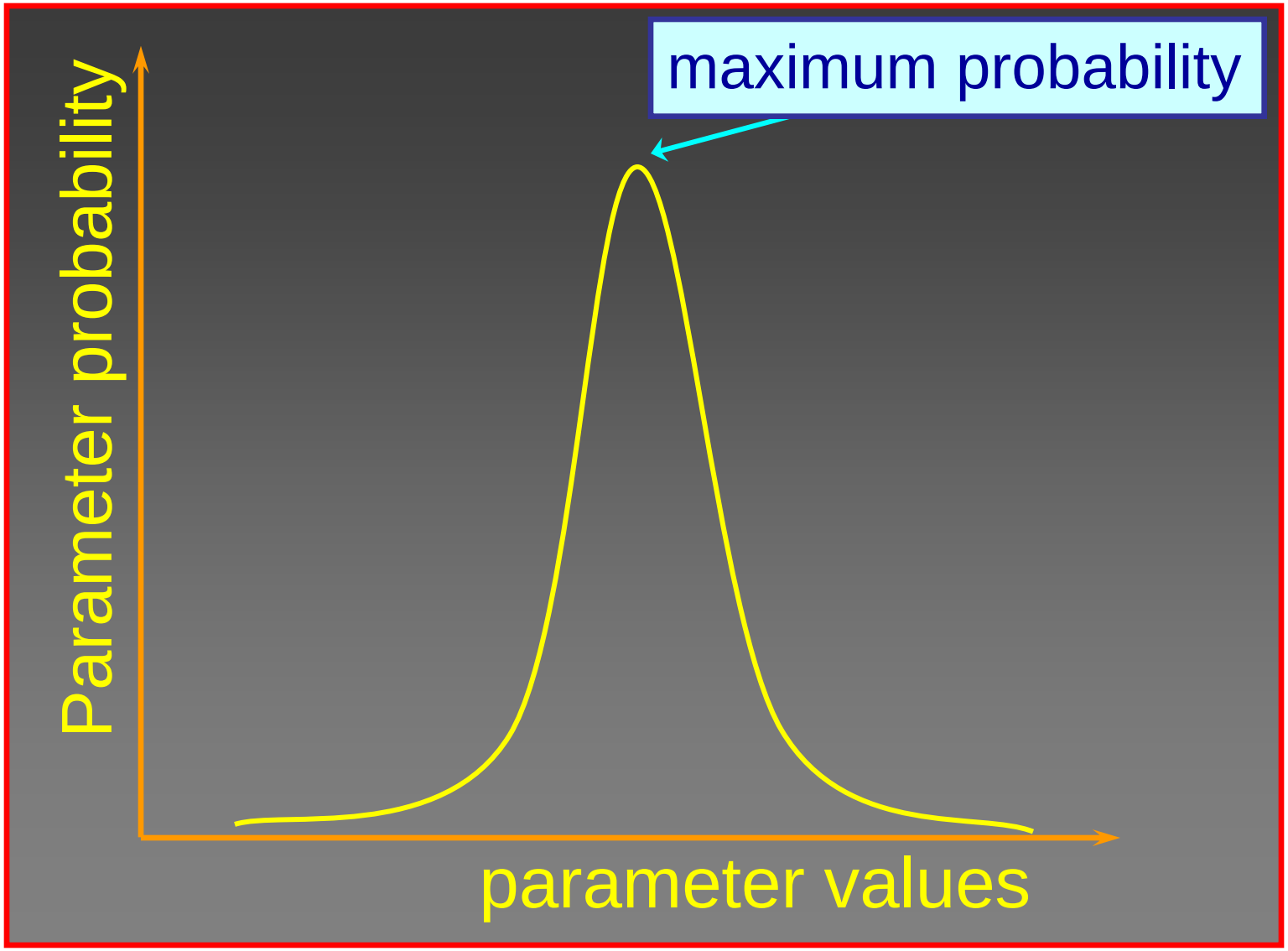
Probability

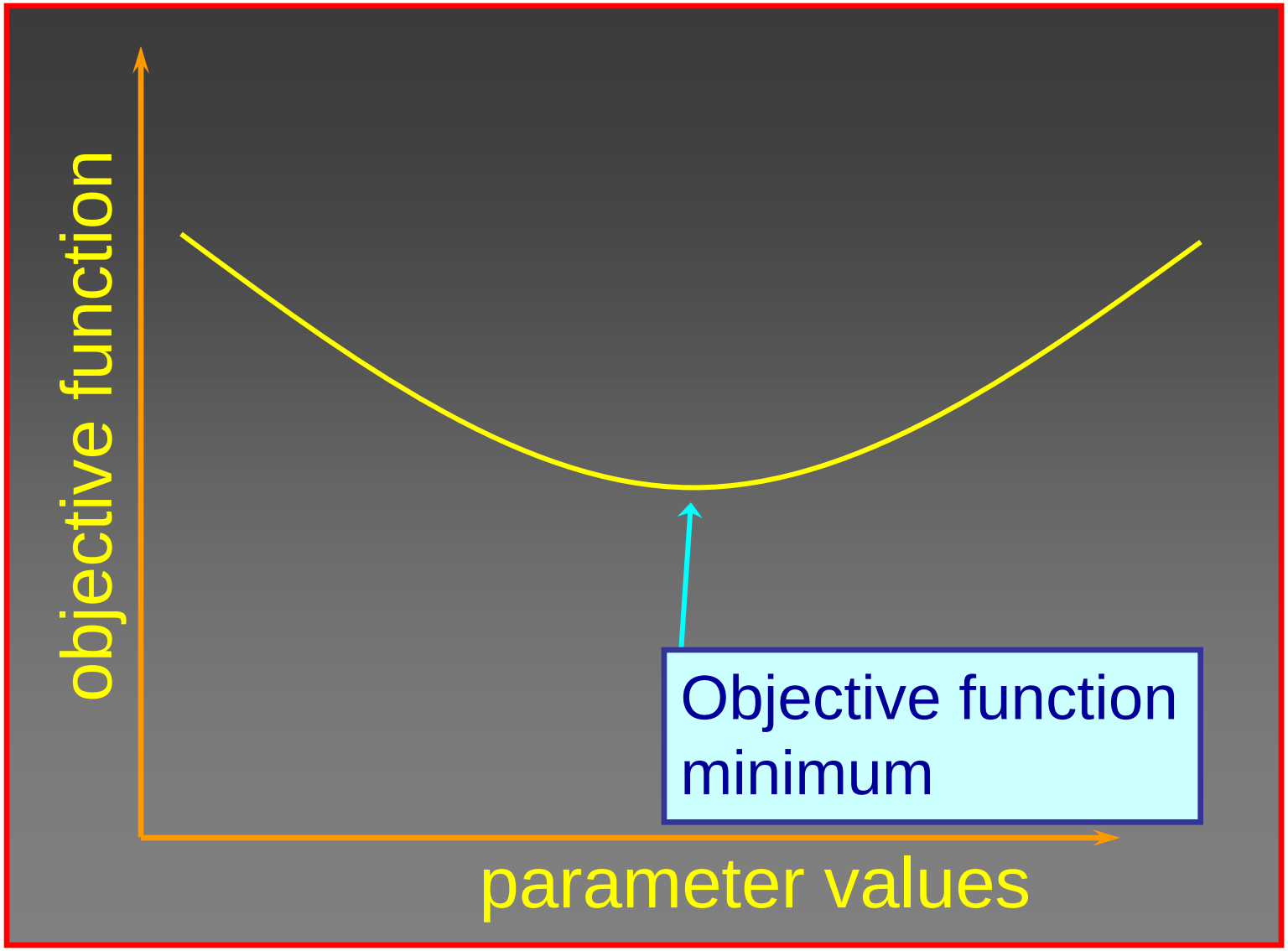
- We can estimate the probability of FUNCTIONAL parameter values
  - Assuming our model adequately captures the important aspects of the system we are modeling

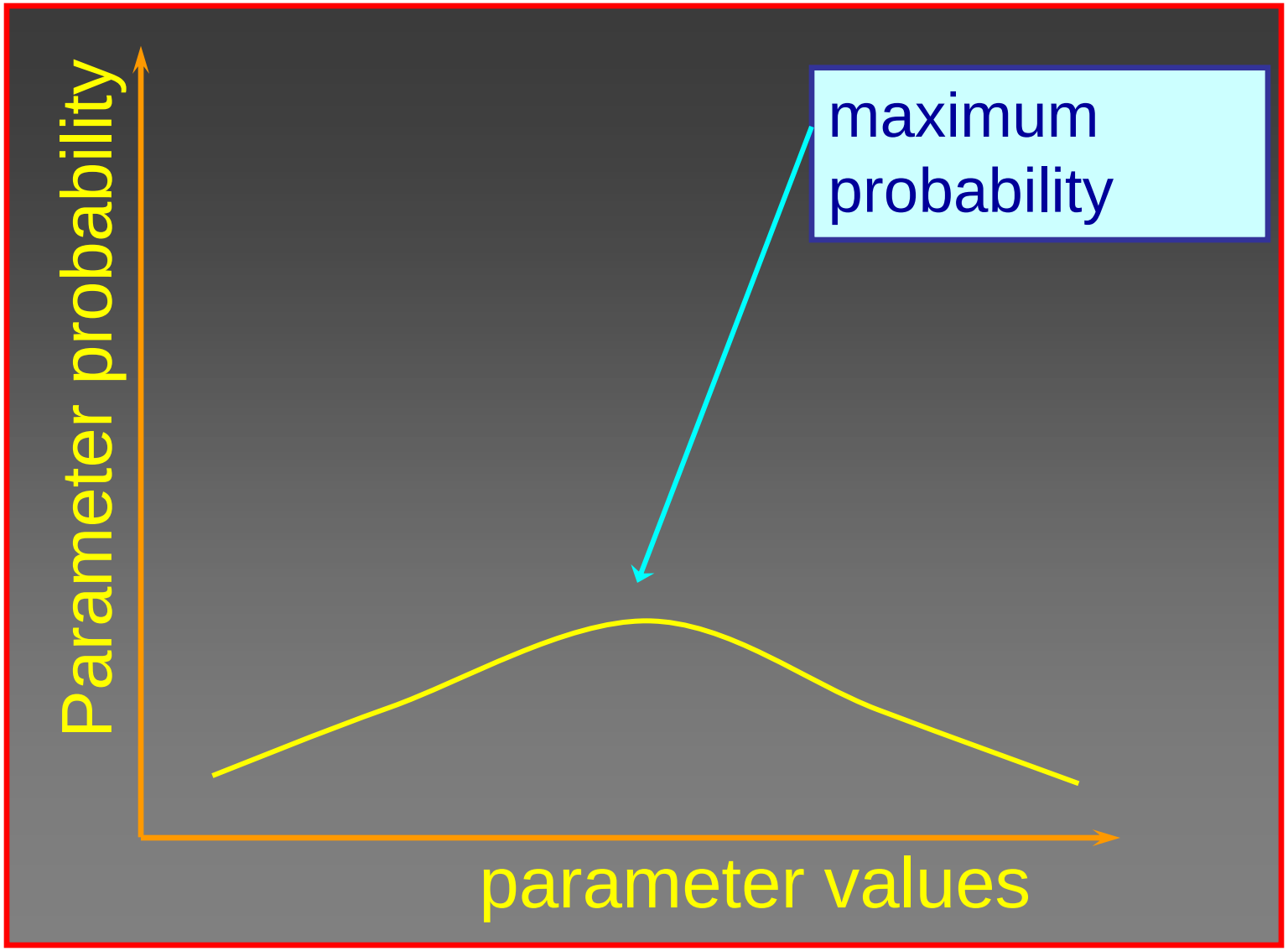

Maximum probability for p_1 , p_2
p_2
p_1


p_2
Objective function minimum
p_1

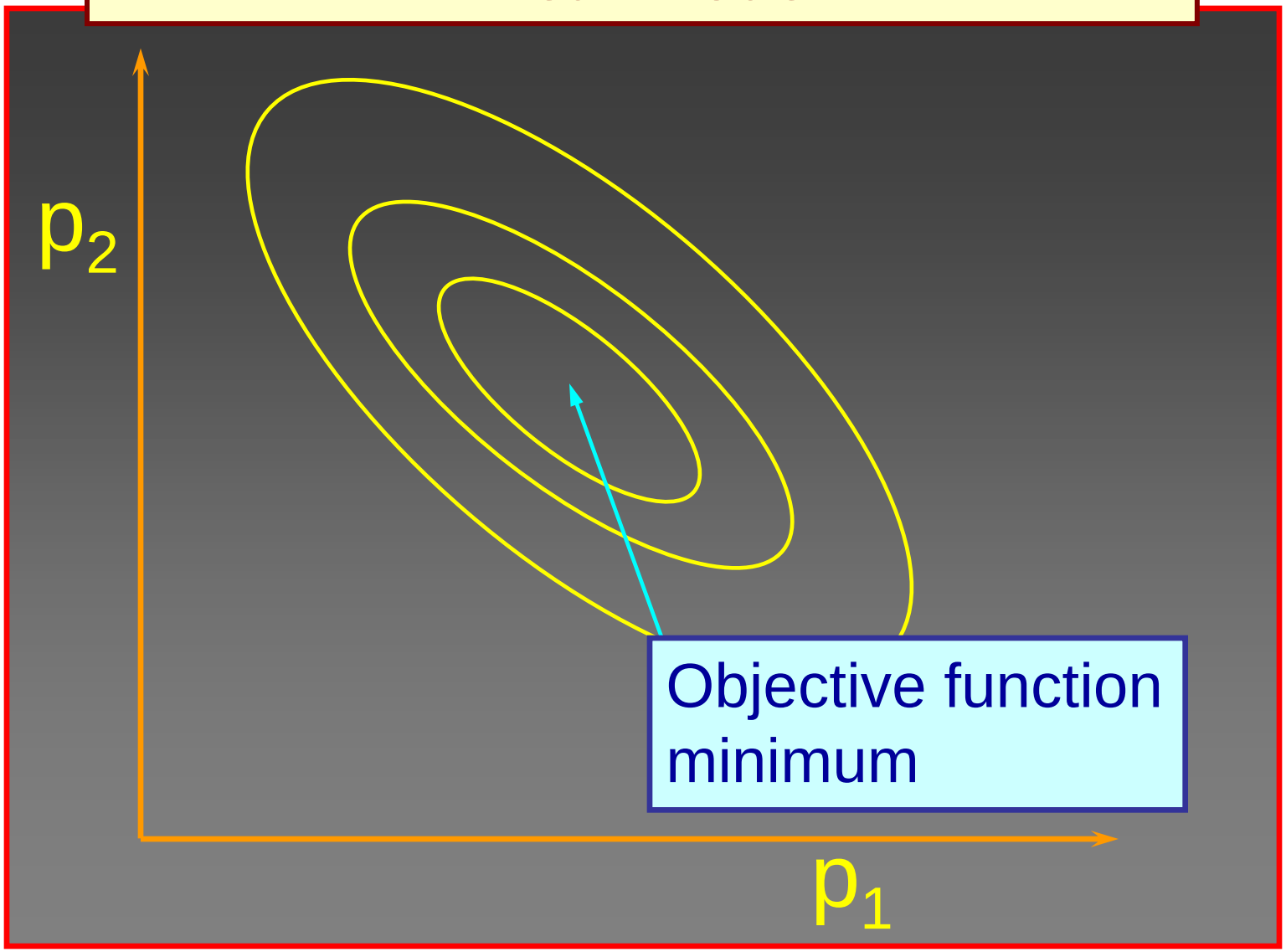

objective function
parameter values
Objective function minimum


maximum probability
Parameter probability
parameter values

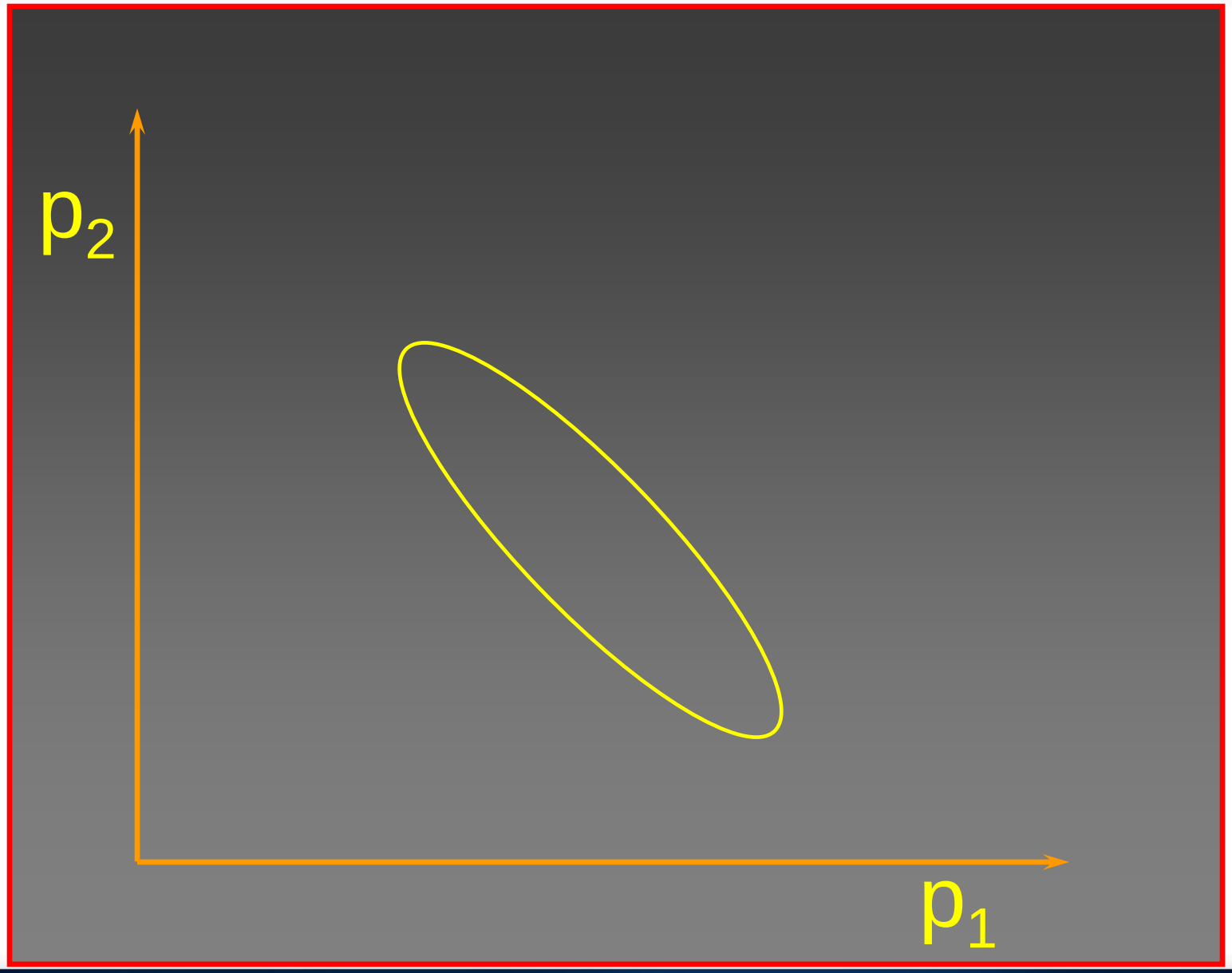

objective function
parameter values
Objective function minimum

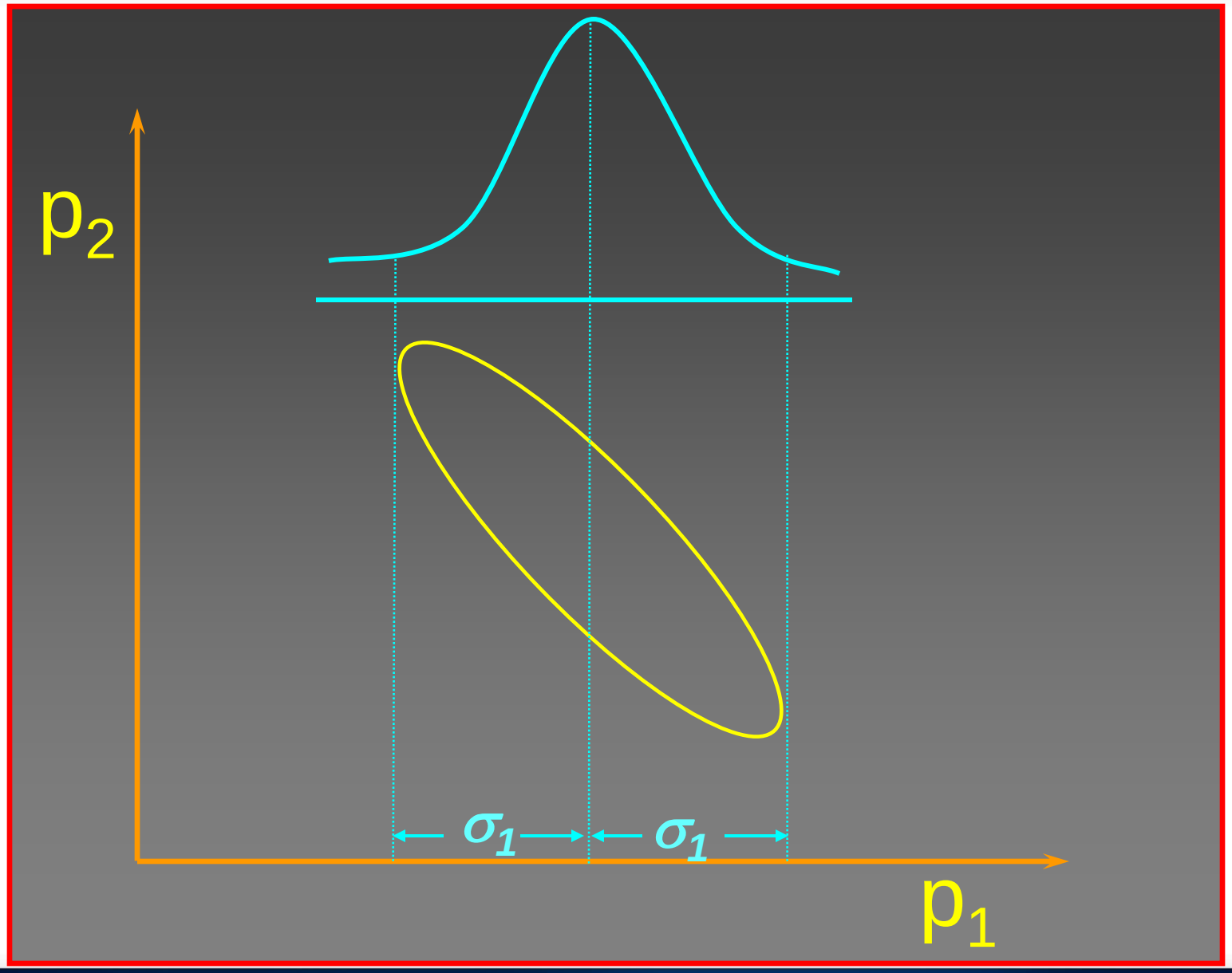

Parameter probability
maximum probability
parameter values

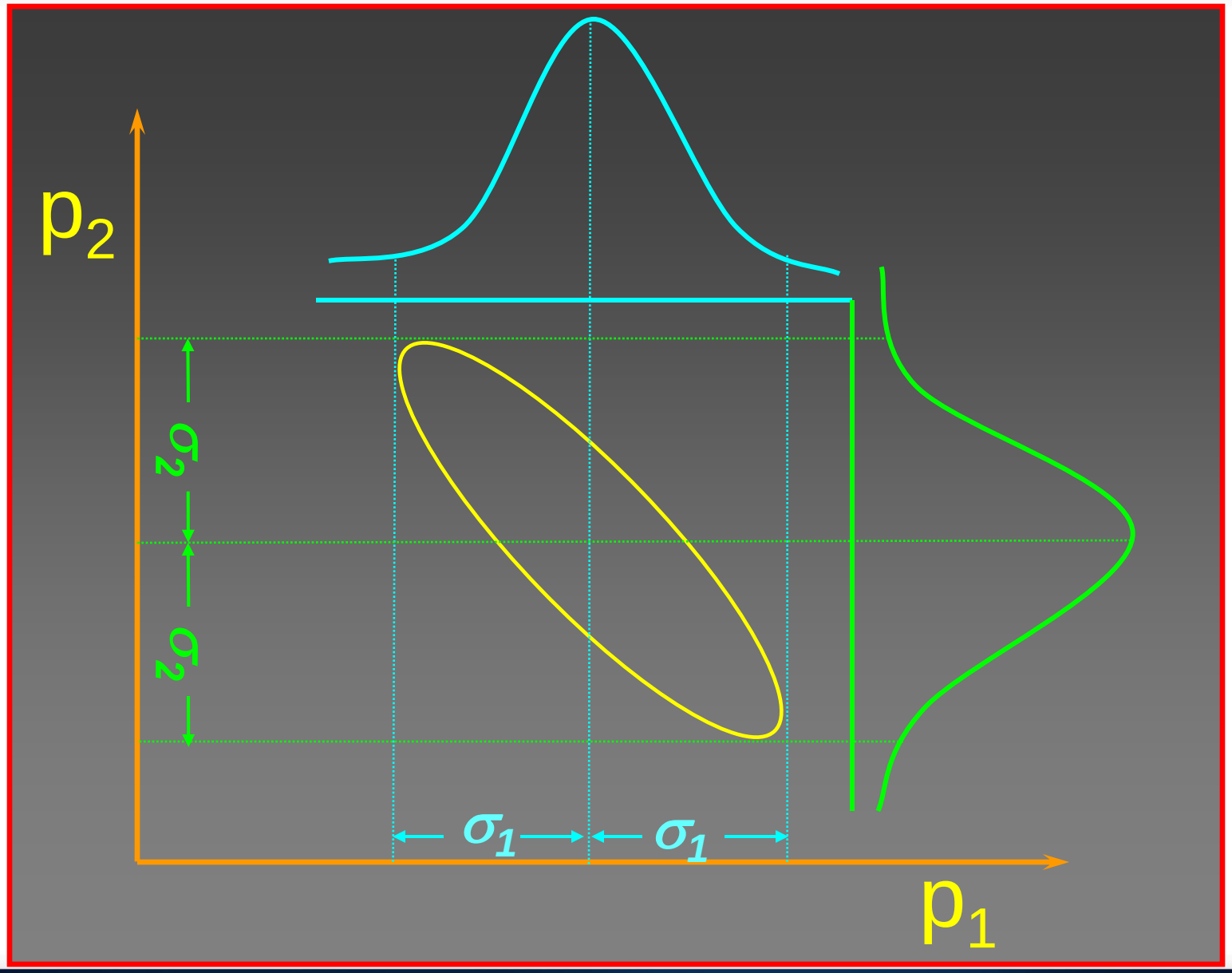
Objective function contours
linear model

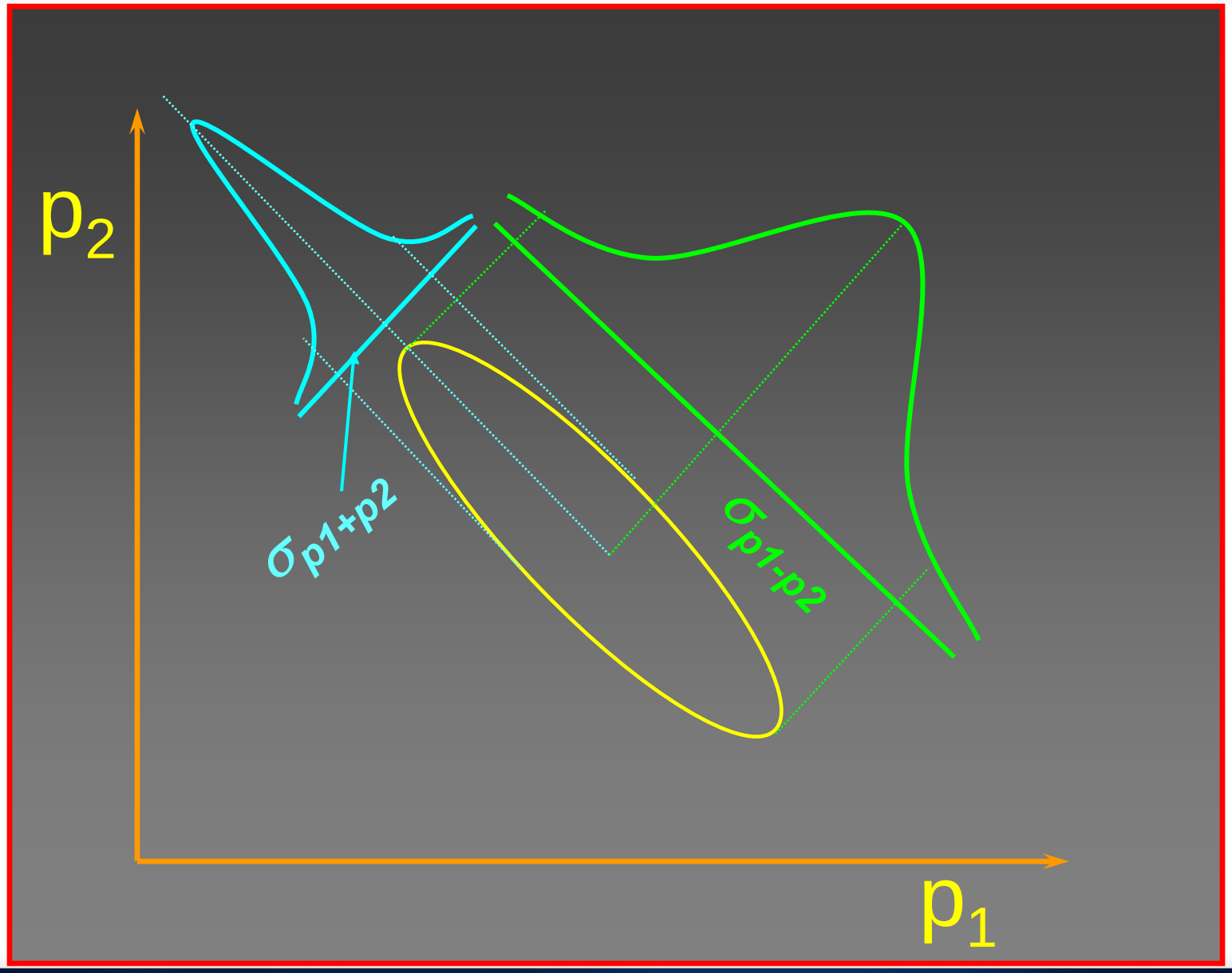


Probability contour



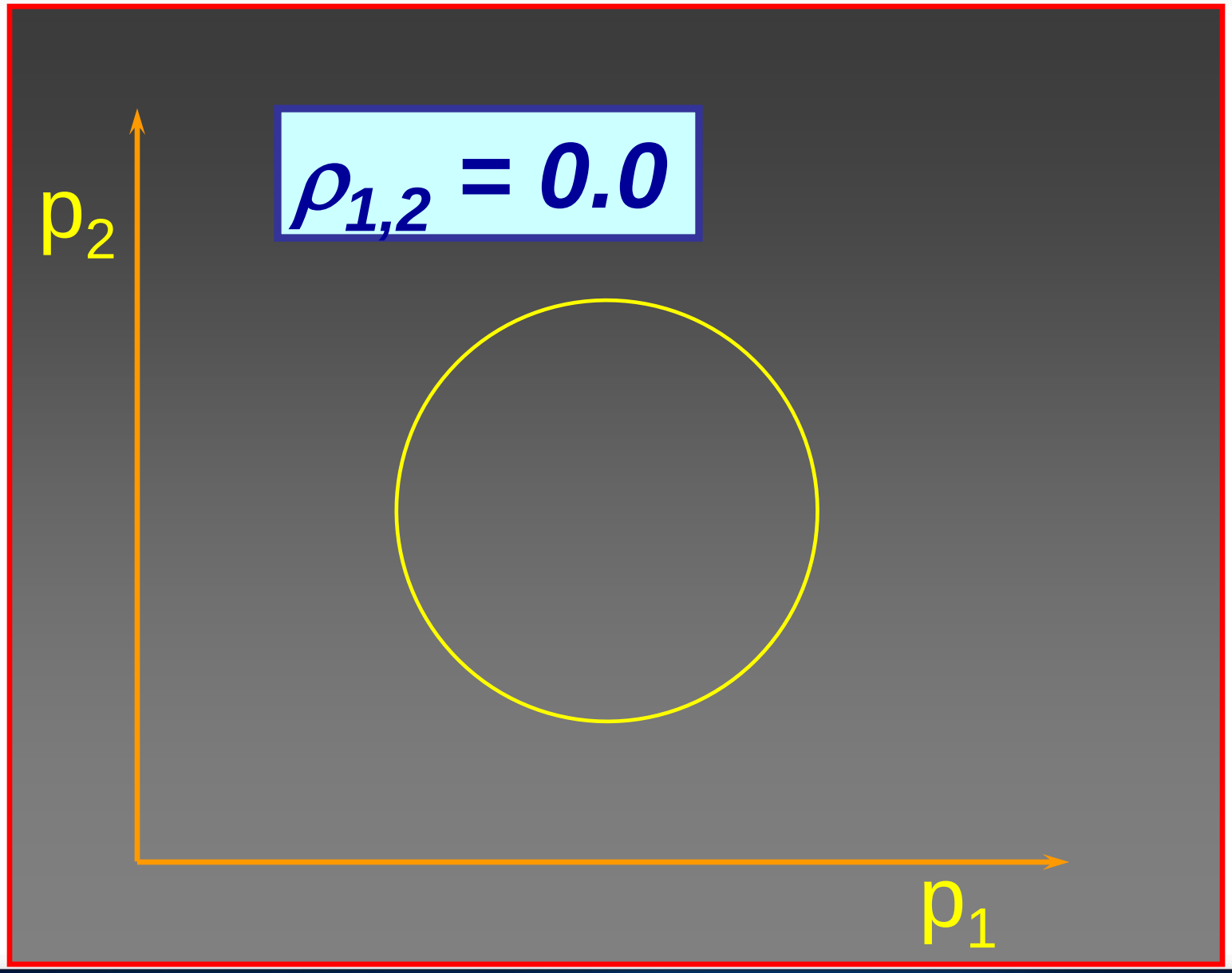

p2
σ1
σ1
p1


p2
σ2
σ2
σ1
σ1
p1

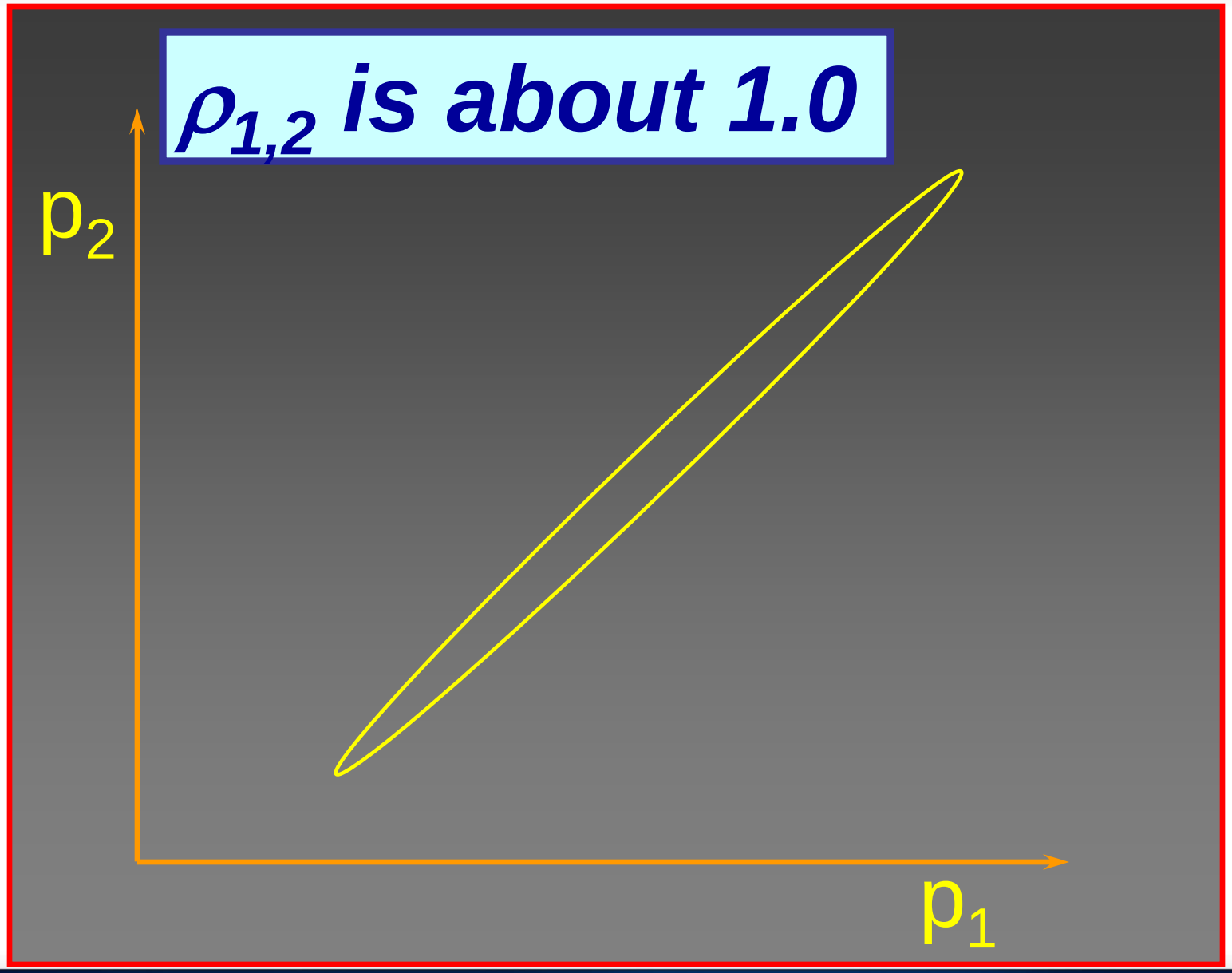

p2
p1
σp1+p2
σp1-p2

Parameter Correlation

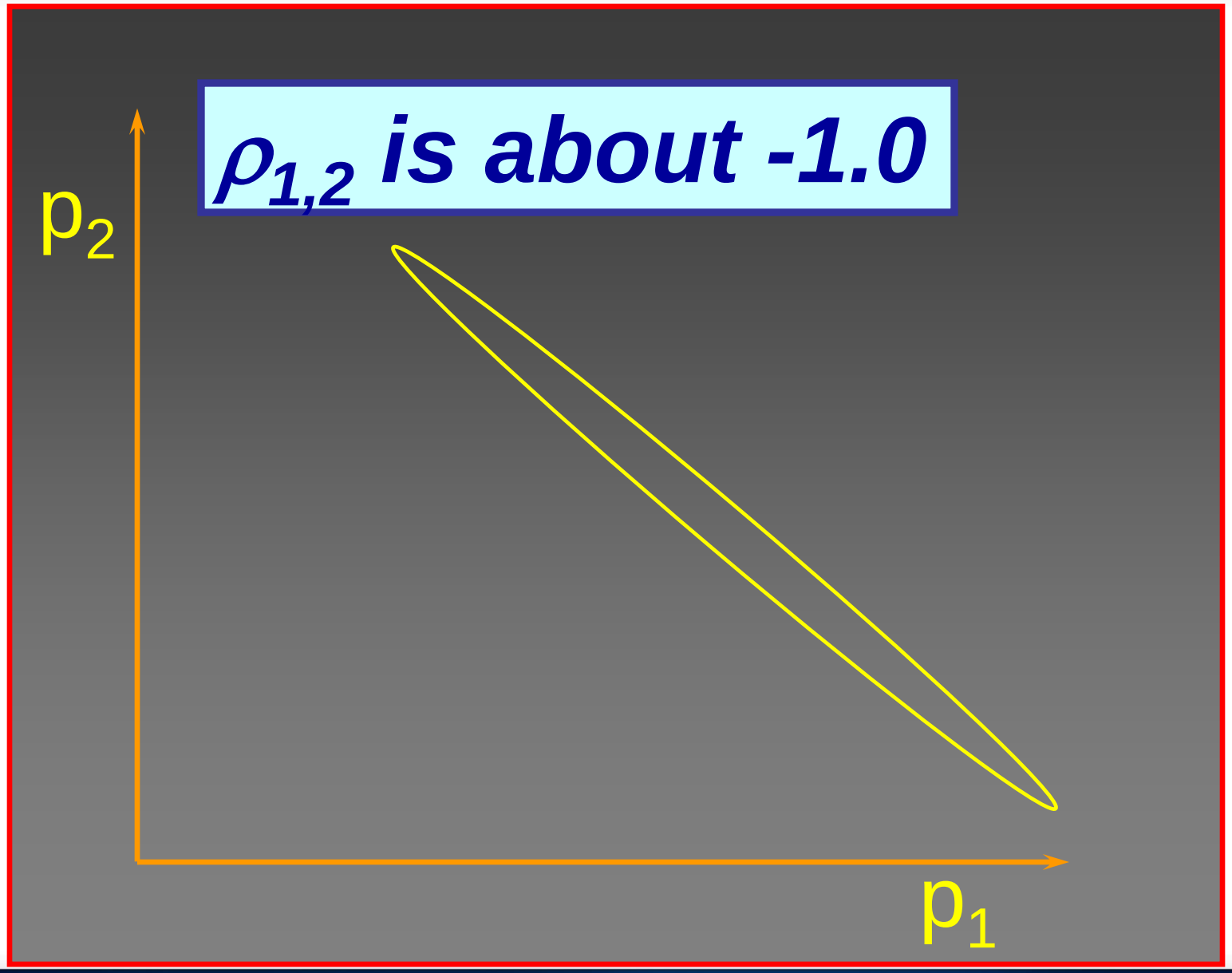
Probability contour



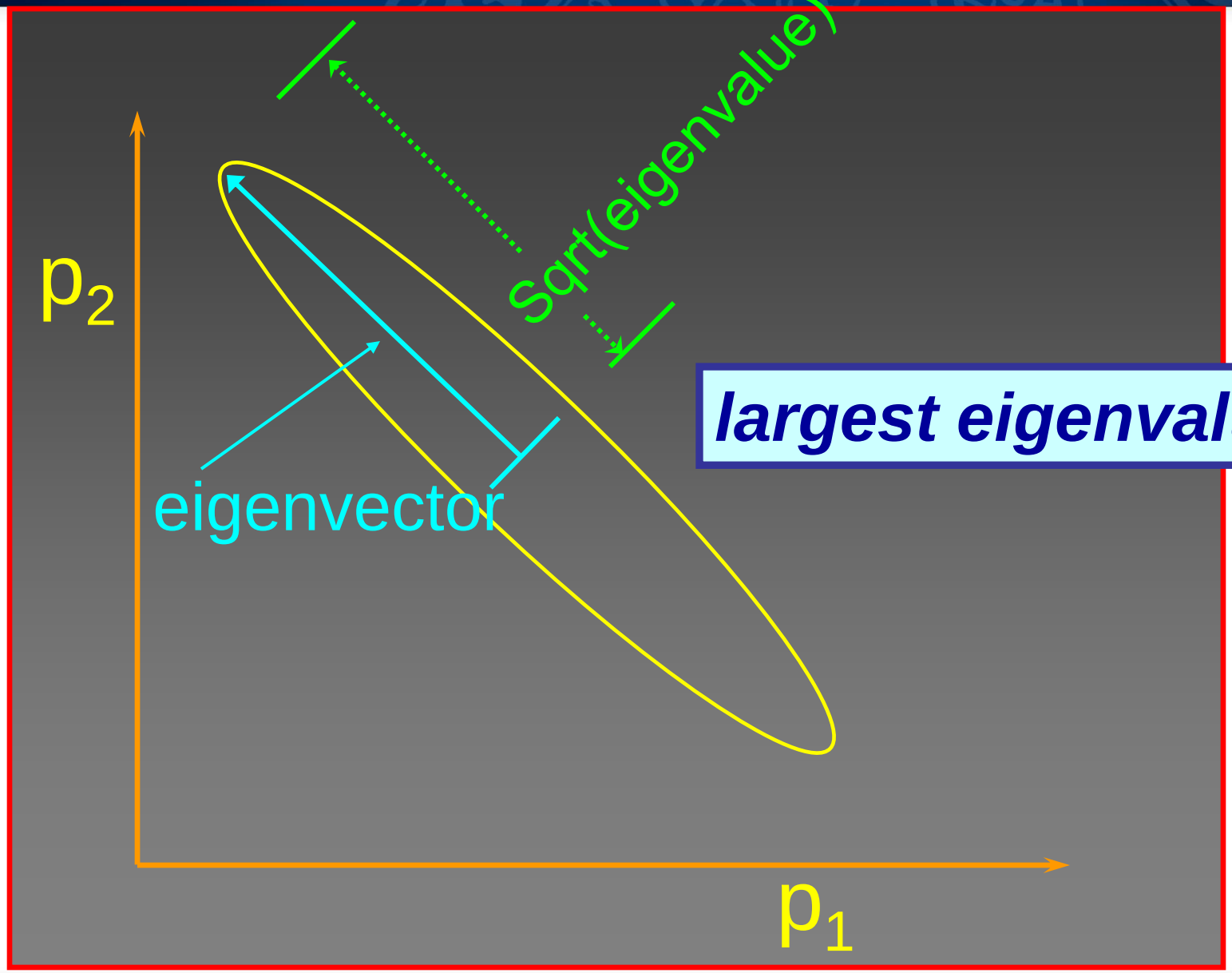
Probability contour



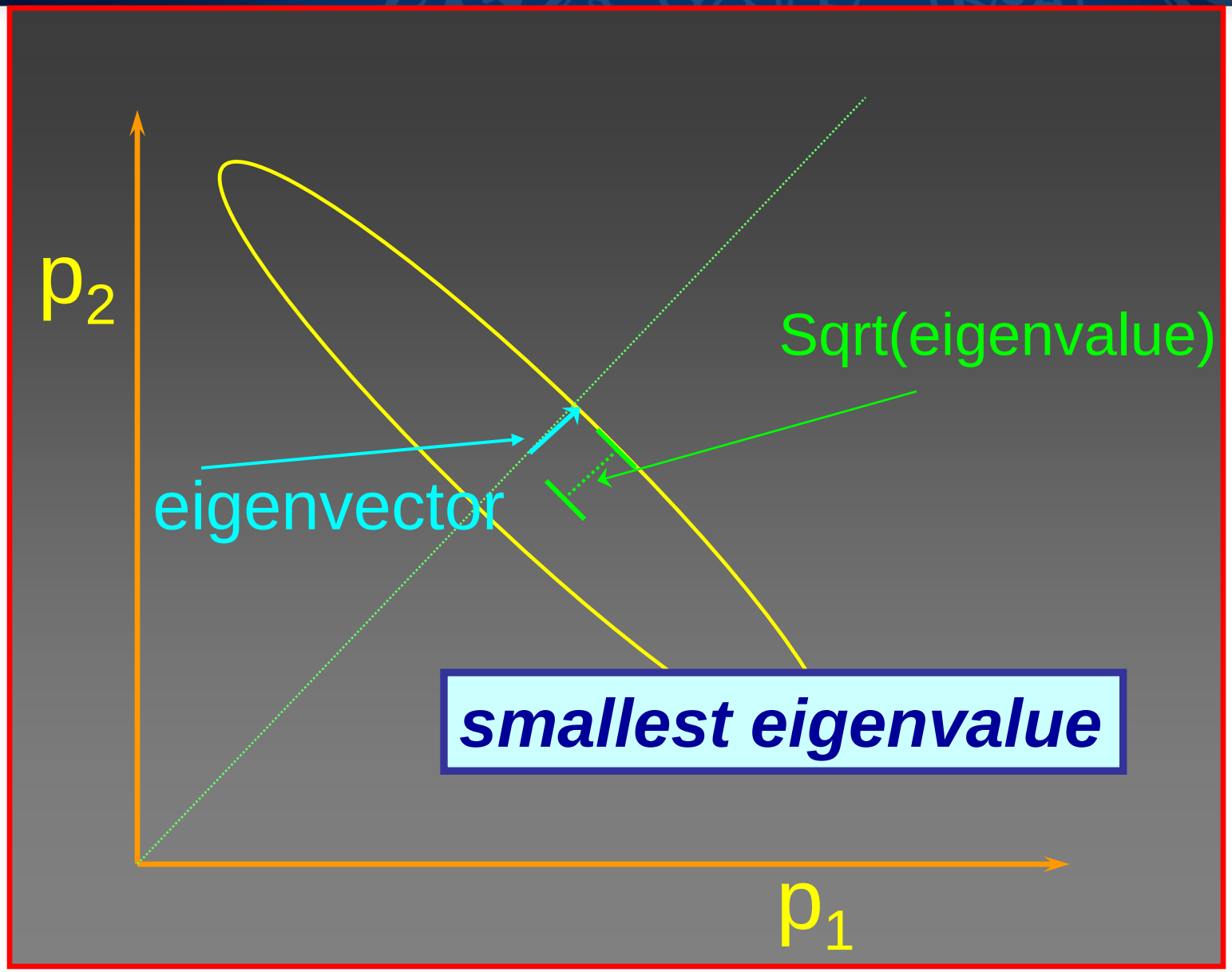
Probability contour



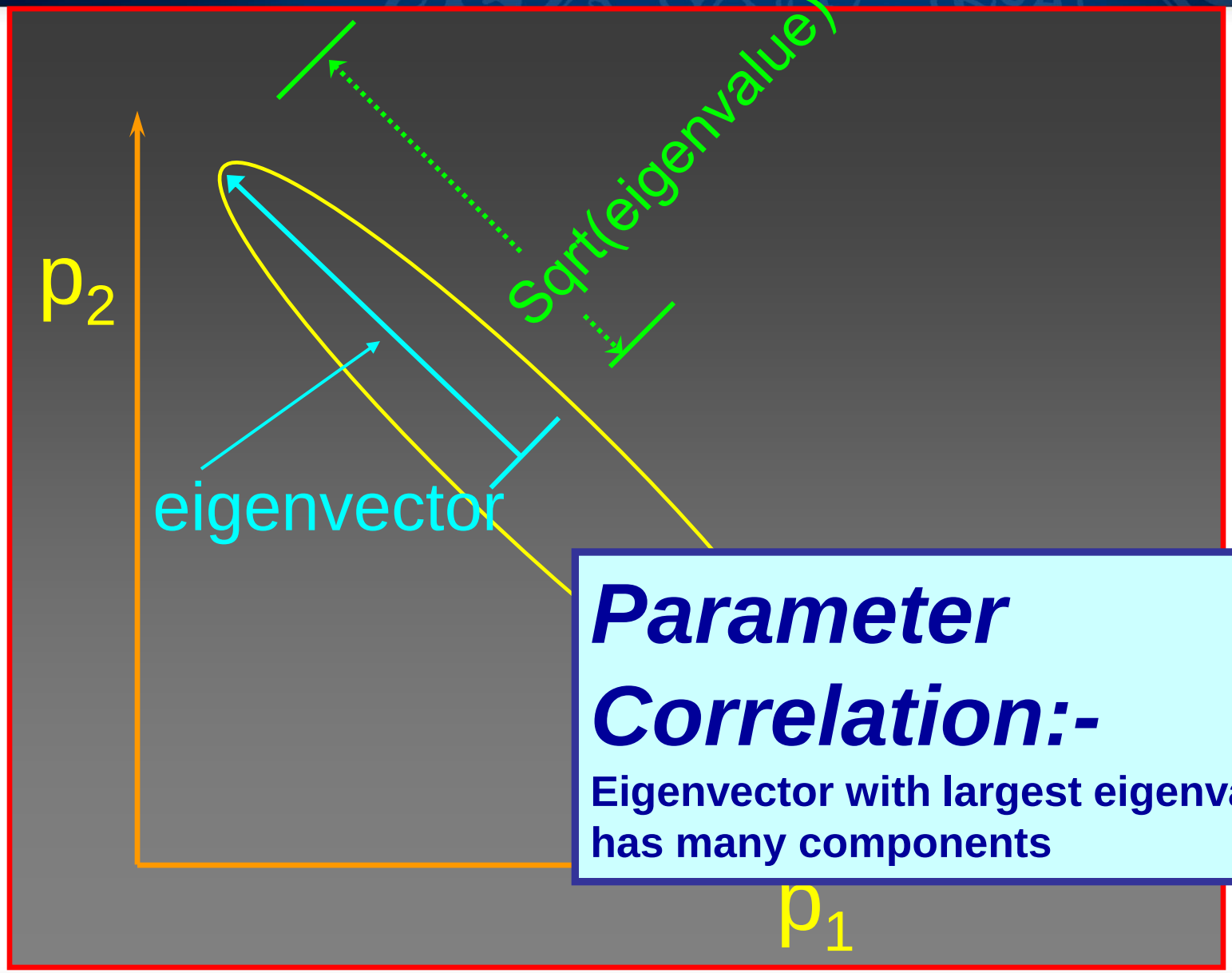
Probability contour



Probability contour



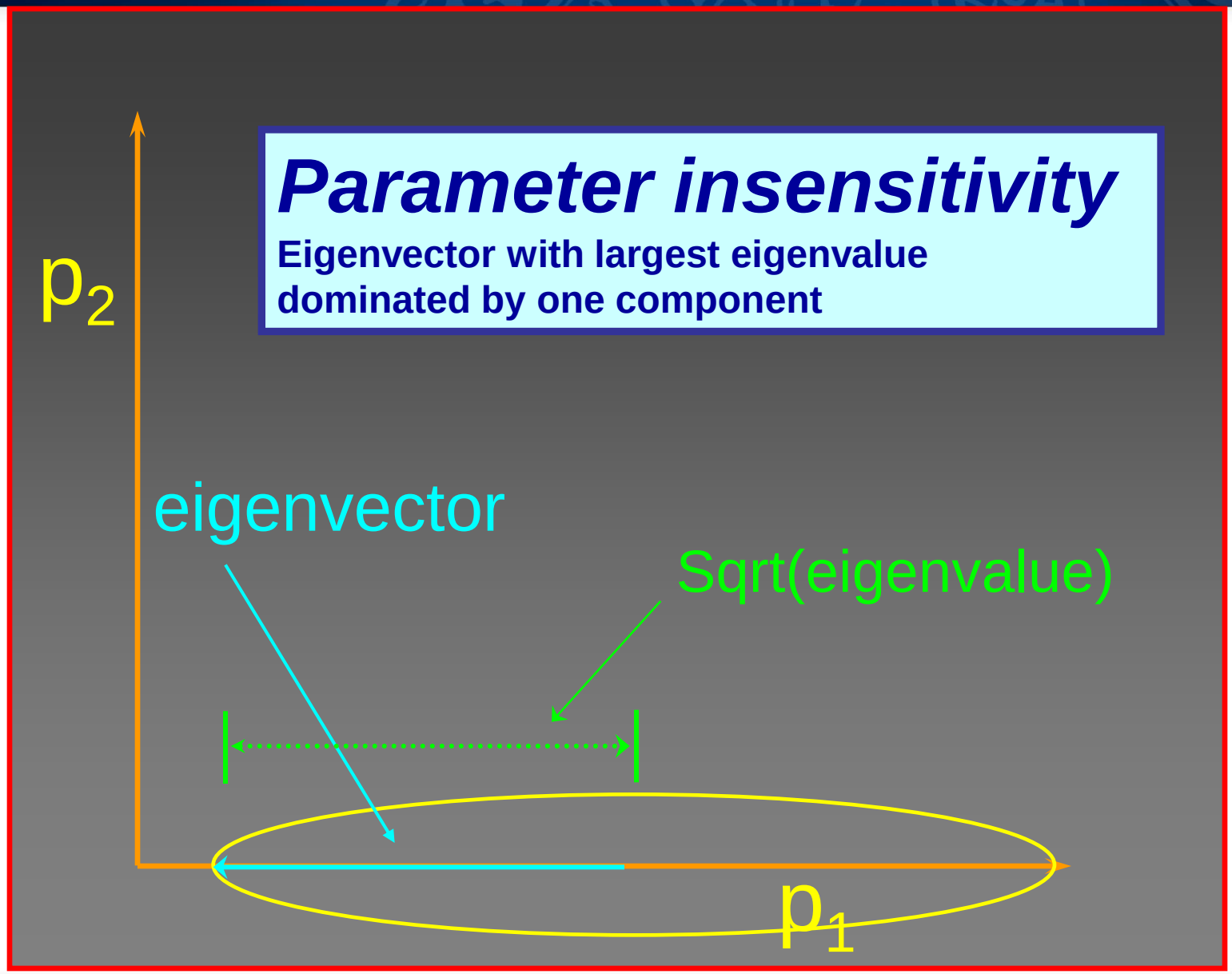
Probability contour



Parameter Correlation:-

Eigenvector with largest eigenvalue has many components

Probability contour



In general, the more linear is the model, the better.

Linearity can often be improved by estimating the logs of certain parameters rather than the parameters themselves.

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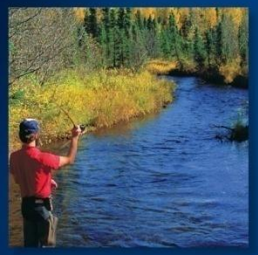

End